SCHOOL OF CIVIL ENGINEERING

INDIANA DEPARTMENT OF HIGHWAYS

JOINT HIGHWAY RESEARCH PROJECT

FHWA/IN/JHRP-87/6

Final Report

IMPLEMENTATION PROGRAM TO IMPROVE EMBANKMENT DESIGN AND PERFORMANCE WITH INDIANA SOILS

A. G. Altschaeffl
S. Thevanayagam
G. Agrawal

PURDUE UNIVERSITY

JOINT HIGHWAY RESEARCH PROJECT

FHWA/IN/JHRP-87/6

Final Report

IMPLEMENTATION PROGRAM TO IMPROVE EMBANKMENT DESIGN AND PERFORMANCE WITH INDIANA SOILS

A. G. Altschaeffl
S. Thevanayagam
G. Agrawal

FINAL REPORT

"Implementation Program to Improve Embankment Design and Performance with Indiana Soils"

To: Harold L. Michael, Director
Joint Highway Research Project

1 July 1987

Project: C-36-5Q

From: A. G. Altschaeffl, Research Engineer

File: 6-6-17

Please find attached the Final Report on HPR, Part II Study entitled, "Implementation Program to Improve Embankment Design and Performance with Indiana Soils". The report was prepared by A. G. Altschaeffl, S. Thevanayagam, and G. Agrawal, of our staff.

The study has fulfilled its objective of enlarging the data base on the behavior of soils compacted in the field. Charts, diagrams and tables have been prepared for the full range of soils of the total data base available. These are ready for use by the practicing engineer to: 1) create the compaction specification that will assure the presence of desired selected behavior parameter magnitudes in the field compacted product; or 2) predict the magnitudes of field behavior parameters from only inspection testing results. These capabilities represent significant additions to the state-of-the-art of earthwork engineering.

The findings from the study clearly show that the range of water content allowed on the lift at the time of compaction controls the variability of the behavior parameter magnitudes. To make best use of the capabilities offered by this study, control of the range of water content must become a major component of the compaction specification.

This Final Report is submitted for review and approval as fulfillment of the objectives of this project.

Respectfully,

A. G. Altschaeffl, P.E.
Research Engineering

AGA:cr

cc: A.G. Altschaeffl
J.M. Bell
M.E. Cantrall
W.F. Chen
W.L. Dolch
R.L. Eskew
A. Fendrick
J.D. Fricker
D.E. Hancher
R.K. Howden
M.K. Hunter
J.P. Isenbarger
J.F. McLaughlin
K.M. Mellinger
R.D. Miles
P.L. Owens
B.K. Partridge
G.T. Satterly
C.F. Scholer
K.C. Sinha
C.A. Venable
L.E. Wood
T.D. White

FINAL REPORT

"Implementation Program to Improve Embankment Design and Performance with Indiana Soils"

by

A. G. Altschaeffl
Professor of Civil Engineering
and
S. Thevanayagam
G. Agrawal
Graduate Instructors in Research

Joint Highway Research Project
Project No.: C-36-5Q
File No.: 6-6-17

Prepared as Part of an Investigation

Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in cooperation with
Indiana Department of Highways

and

Federal Highway Administration
U.S. Department of Transportation

Purdue University
West Lafayette, Indiana

1 July 1987

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/IN/JHRP-87/6		

4. Title and Subtitle	5. Report Date
"Implementation Program to Improve Embankment Design and Performance with Indiana Soils"	July 1, 1987
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
A. G. Altschaeffl, S. Thevanayagam and G. Agrawal	JHRP-87/6
9. Performing Organization Name and Address	10. Work Unit No.
Joint Highway Research Project Civil Engineering Building Purdue University West Lafayette, IN 47907	11. Contract or Grant No. Indiana HPR-2365-(024),Part II
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Indiana Department of Highways State Office Building 100 North Senate Ave. Indianapolis, Indiana 46204	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration under a research study entitled "Implementation Program to Improve Embankment Design and Performance with Indiana Soils"

16. Abstract

Several Indiana soils compacted in field and laboratory were tested for engineering behavior in-service. Data were blended into those of a previous project to allow more effective predictability of behavior.

For each of low plasticity and moderate plasticity soils, procedures were created that allow: (1) creation of the earthwork specification that will assure the presence of a desired selected behavior parameter magnitude in-service; (2) prediction of field behavior parameters using only inspection test results. These are major strides in earthwork engineering.

The most important characteristic in the achievement with assurance of the best possible in-service behavior parameters is the range of water content allowed in the lift. This range controls the parameters' variability. Control of this range must be part of the earthwork specification if best use is to be made of the innovative procedures of this study.

It is strongly urged that users of these procedures make a continuing effort to add new data to the data base to allow more widespread effective earthwork.

17. Key Words	18. Distribution Statement
Soils, plasticity, earthwork engineering	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	185	

Form DOT F 1700.7 (8-69)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Appendix Figure		Page

LIST OF ABBREVIATIONS AND SYMBOLS

AASHTO	-	American Association of State Highway and Transportation Officials
CIU test	-	Isotropically Consolidated Undrained Shear Test
IDOH	-	Indiana Department of Highways
PSD	-	Pore Size Distribution
SPSS	-	Statistical Package for the Social Sciences
UU test	-	Unconsolidated Undrained Shear Test
c'	-	effective stress strength intercept (kPa)
e	-	void ratio
e_o	-	initial void ratio
F	-	overall F-test value (a statistical measure of the significance of the variables)
I_p	-	Plasticity Index
pcf	-	pounds per cubic foot
psi	-	pounds per square inch
P_c	-	compaction pressure,(compaction energy) (kPa)
P_o	-	confining pressure (kPa)
P_s	-	as compacted prestress (kPa)
q_c	-	confined undrained shear strength, $\left(\frac{\sigma_1 - \sigma_3}{2}\right)_f$, (kPa)
R^2	-	coefficient of multiple determination
S_i	-	saturation index (%)
SP_s	-	saturated prestress (kPa)

$V_{(w)}$ - half-range of water content variability (%)

W_c - water content (%)

γ_d - dry density (kg/m^3), (kg/cu.m.)

$(\frac{\Delta V}{V_o})$ % - one-dimensional percent volume change on soaking

ϕ' - effective stress strength angle (degrees)

σ_1 - major principal stress (kPa)

σ_3 - confining stress (kPa)

σ_v - vertical stress (kPa)

CONVERSIONS

U.S. Customary	SI Equivalent
in	0.0254 m
ft	0.3048 m
lb f	4.45 N
psi	6.895 kPa
psf	47.88 N/sq m
lb f /cu.ft	0.1572 kN/cu.m

EXECUTIVE SUMMARY

This study was created to enlarge the data base on the behavior of Indiana soils compacted in the field. The predecessor HPR, Part II, study was entitled, "Improving Embankment Design and Performance". That study created procedures that markedly could improve the engineer's capability in predicting the behavior of field compacted soil. The present study sampled and tested new soils and blended their data into those of the predecessor study. This report presents the results of the total accumulation of data from both studies.

The results are presented for 2 situations of use to the engineer, and the soils are divided into 2 categories. In both studies, the contractor was allowed to use whatever roller was believed to be effective and efficient for the earthwork. Remarkably, almost all projects were compacted with 1 roller, the Caterpillar 825; there is no discrimination made in these results among rollers, for no major differences were found.

For each of the 2 soil categories, low plasticity and moderate plasticity, charts and diagrams were prepared, and are presented, for use in DESIGN ENGINEERING. In this option it is assumed that the soil borrow is identified well in advance of construction so that it can be established that this soil fits the data base of the study. The design engineer then selects the magnitudes of behavior parameters he desires in the compacted

product. The study charts and diagrams indicate which sets of compaction variables will yield those parameters. The engineer selects which specification best creates the behavior pattern desired. If none are suitable, then the option can be recycled with different behavior parameter criteria. For the compaction specification that is selected, the charts will yield those parameters that the engineer can expect to be present, with assurance, in the compacted product. Thus, the engineer can <u>control</u> the behavior of the embankment by judicious use of the study results.

For each of the 2 soil categories, a computer program and sample tabulations were prepared, and are presented, for the QUALITY ASSURANCE option. It is assumed that the borrow for the project has <u>not</u> been identified well in advance of construction. In this option it is desired to know what behavior parameters have been produced by the compaction. It is necessary to obtain identification test results so to be certain the soil being used fits the data base. Then are required the results of inspection test results on the lift. From these results one can locate the appropriate tables that fit the soil characteristics; these tables will yield the behavior parameters that can be expected, with assurance, for the compacted product. If these parameters are not tolerable, the engineer could then invoke the DESIGN ENGINEERING option for subsequent earthwork on the project.

The study indicated clearly that the <u>range of water content</u> on the lift is the most important characteristic of the earth to be compacted. This range of water content controls the variability of the behavior parameters. Thus, to achieve the best possible parameters, with assurance, requires control of the allowable range of water content. This control must be part of the earthwork specification if best use is to be made of the innovative procedures from this study.

The results presented in this report represent major strides in the improvement of the state-of-the-art of earthwork engineering. These improved capabilities strongly urge that a continuing effort be made to continue to add to the data base. It is only in this way that more widespread effective earthwork will be performed.

Section 1

INTRODUCTION

Soil compaction is one of the most effective means of improving the engineering behaviour of these earthen materials. To improve the effectiveness and efficiency of the compaction process, several investigations have been made at Purdue University. This report summarizes the results of the latest investigation, which includes the assembly of data previously obtained.

The thrust of this work is the improvement in the engineer's ability to predict the in-service behaviour of compacted soils. In the past,the behaviour parameter magnitudes were not included in any earthwork specification. These magnitudes always were obtained in an indirect manner, often using laboratory compacted conditions. Field compaction is specified in terms of dry density, water content, and compaction energy (usually related to that induced by some some "standard" laboratory test procedure). The inference has been that parameters could satisfactorily be obtained if one tests the same soil compacted in the laboratory to the same dry density and at a water content in the same region of the optimum water content as will be done in the field.

The realization that laboratory and field compacted

soils will behave differently has led to very conservative uses of the behaviour parameters (where field test embankments are not constructed). This situation does not allow most effective and efficient use of Compacted earth.

An earlier HPR, Part II, study, entitled "Improving Embankment Design and Performance" created procedures to improve the engineer's capability to predict behaviour. Exhaustively testing two soils compacted both in the field and in the laboratory, this project created procedures to improve two situations. First, when the engineer knows the borrow in advance of construction, charts were prepared to allow the selection of the combination of compaction variables that would produce the magnitude of behaviour parameter that was desired in the field. The engineer can select a desired parameter magnitude and the procedures indicate which specification will <u>assure</u> the creation of that magnitude. This markedly improves the engineer's design capability. Now, there can be control over the parameter magnitudes and,thus, such structures as slopes can be designed to criteria for safety in a more controlled manner. This situation has been called DESIGN ENGINEERING.

The second situation addressed by the former project involved cases of earthwork where the borrow was not defined prior to construction. In this case, the specification cannot be determined uniquely as before, nor can desired parameter magnitudes be selected. Nevertheless, the

behaviour parameter magnitudes are required because design analyses must be performed. The created procedures allow the prediction of the behaviour parameters using soil identification data and the results of the inspection testing performed for that soil compaction.Knowing the dry density, average water content, range of water content, and compaction energy will allow the prediction to be made. One may not be able to regulate the parameter magnitudes, but one will know what they are. This situation has been called QUALITY ASSURANCE.

The work of the foregoing project was enhanced by a companion HPR, Part II, study entitled "Effects of Pore-Size Distribution on Permeability and Frost Susceptibility of Selected Subgrade Materials." This study concluded that the distribution of the sizes of the voids in the compacted earth can describe quantitatively the "soil fabric." This fabric, i.e., the composition and arrangement of constituent particles, controls behaviour. The pore-size-distribution appears to be a possible numerical bridge between the compaction variables and the behaviour parameter magnitudes. Its usefulness was not yet proven for earthwork behaviour prediction and control, but the possibilities seemed promising.

The foregoing capabilities were significant additions to the state-of-the-art, but they were useful only for the 2

soils studied. Accordingly, there was funded the project to which this report pertains, to examine the possibilities of generalizations of the capabilities to other soils over a wider spectrum of characteristics.

Section 2

OBJECTIVES OF THE PRESENT STUDY

The primary purpose of this study is the enlargement of the data base on the behaviour of Indiana soils compacted in the field. The enlargement was to include:

(1) Soils of different geologic origin but similar to those of the previous project;

(2) Similar soils compacted with different rollers;

(3) Different soils.

A secondary purpose was to continue the work on pore-size-distributions as descriptors of fabric. This was to try to show the extent of their usefulness and acceptance for practice.

The effort of this study to enlarge the range of usefulness of the capabilities created by the predecessor project was to be done in concert with the IDOH construction program. Data on field compacted soil behaviour were to be obtained from samples taken from on-going construction, Thus, the soils actually sampled and tested were selected from those being used in construction at the time of the start of this study. The objectives and results of this study must be viewed in light of this constraint.

Section 3

FINDINGS FROM THE STUDY

3.1 Introduction

The work of this study has corroborated the concepts created in the previous project. The data base has been enlarged, new and old data have been blended, and the relationships have led to the suite of charts and diagrams that are presented in this report. Thus, the results of this study are comprehensive in that the earlier data are included in the presentations.

The studies have led to two capabilities : (1) when borrow is known prior to construction, the engineer now can select the soil compaction specification which will assure the presence of desired selected behaviour property parameters; charts and diagrams guide his selection; this situation and procedures have been called DESIGN ENGINEERING; (2) when borrow is not known in advance of construction, the engineer can determine what behaviour property parameters will be present for the compacted product, without extensive sampling and testing except for routine inspection testing; tabulations from a computer program guide these determinations; this situation and procedures have been called QUALITY ASSURANCE.

The charts, diagrams, computer programs and tabulations are the focus of this report. It is the purpose of this report to present them in a manner usable by the engineer for the purposes noted above. The text is intended to facilitate their use and to explain the bounds of their validity. To this end, material that is somewhat extraneous to the use of these results has been placed in an appendix or excluded from the report.

3.2 The Bounds of Validity

3.2.1 Soils and rollers in study

3.2.1.1 Soils

The characteristics, origin, location, range of water content, and compaction energy for which data are available are shown in Table B.1. The charts and diagrams in this report are constrained to these data and their ranges. It is difficult to constantly mention the bounds of the data base. However, these bounds represent the extent of the validity of the relationships; using these relationships beyond these bounds will represent an extrapolation whose quality can not be judged.

The soils that were used in this study were selected from those present in on-going IDOH road construction projects. The borrow was sampled, identification tests were followed by determination of compaction characteriatics.The

compacted lifts were also sampled and behaviour properties were determined by test. It was found that the blending and mixing performed during construction created soil characteristics different from the borrow sampling. Thus, for example, while the Fort Wayne and Avon sites (see Table B.1) were expected to be moderately plastic soils, in fact, the placed blended soil belonged to the low plastic soil category. The final array of soils used contains the data for soils as actually placed. The quirks of the construction operations caused the seeming imbalance in the data presented.

3.2.1.2 Compactors

No specification control was ever placed on the compactor which the contractor planned to use for earthwork. Remarkably, one was used almost universally, the Caterpillar 825, operated at a speed of about 3 mph. On the test embankment described in the former project at St. Croix, Indiana, a second compactor was used, the Raygo-Rascal 420C, Vibratory drum roller. The two are essentially similar in the amount of energy imparted for a given number of passes,especially if the number of passes is low (see Table 3.1).

In the creation of the relationships for the compacted soils, the energy imparted by the rollers was calculated as suggested by SELIG (11). These energy were then used in the

relations created by the study with no additional roller discrimination being made.These energy determinations are tabulated in Table 3.1.

Table 3.1

Relation Between Compaction Pressure and Roller Passes

Compactor Type	No. of Passes	Compaction Pressure (kPa) (Psi)
Caterpillar 825 (Sheepsfoot)	4 8 16	797 (115) 1204 (174) 1771 (257)
Raygo-Rascal (Vibratory)	4 8 16	780 (110) 1038 (221) 1525 (221)

It should be realized that the compaction was accomplished under differing circumstances depending on location. Data from Anderson and St. Croix sites were obtained from test embankments created as special provisions in the construction contract. Data from other locations were obtained from post-compaction sampling of the results of prototype "routine" project earthwork. No distinction is made among the data; they have been blended and lumped.

3.3 Field Sampling

Locations of field samples were selected using the field inspection data provided by IDOH for each site. Locations were chosen so that samples were collected over the entire water content range within which the compaction was done. It must be noted that the relationships obtained

from this study will give better results within this range of water content. Any extrapolation should be used with engineering judgement.

Samples were obtained with Shelby tube samplers by IDOH personnel and transported to Purdue University. Samples were immediately extruded, waxed, and stored under humid conditions. Testing was done as soon thereafter as possible. A number of samples had large pieces of gravel which caused some disturbance during extrusion. However, in most cases, disturbance appeared to be small in the trimmed samples. Testing was done with care to avoid further disturbance.

Testing procedures were similar to those used by previous researchers and have been described in detail by Liang (5).

3.4 How Results are Presented

The data for the two projects have been blended and placed into two categories : (1) soil of low plasticity, i.e. soils with Plasticity Index between 6 and 13; (2) soil of medium to high plasticity, i.e., soil with Plasticity Index between 17 and 26. Table B.1 shows the characteristics of the soils from which the data base was prepared.

The test data for the soils of this study are presented as Appendix C of this report. Test data from the previous project, comingled with the new data, already have been

published in the previous reports of the predecessor project.

The goal of the study is practical usefulness. In this aim, results are presented differently for the two situations in which they can be useful. For DESIGN ENGINEERING, a flow chart has been prepared to guide one through the procedure (Fig. 4-1). Then a series of charts are presented for each soil category for various combinations of variables and behaviour parameters, to be used as the flow chart indicates. A small section of text describes the approach, or philosophy, of the procedure so as to lead one through the paths of the flow chart. Finally,a small example is presented as illustration of the procedures. The goal is the creation of that compaction specification which will assure the engineer the presence of the desired selected behaviour parameters.

For the QUALITY ASSURANCE situation, a flow chart also has been prepared as a guide (Fig. 5-1). The text explains the procedure. Each of the two categories of soils has had a number of tables prepared, and it is these tables that are used in this situation. An example is also presented to illustrate the procedures. The computer pragram that was prepared to create these tables is presented as Appendix D and can be used to create tables that cover other combinations of variable values than those already presented in the included tables (Table 5.1 to 5.62).

Finally, Appendix B also contains the regression models that were used to create the charts and tables. These models are for the lumped data for each soil category. They differ from the models of the predecessor project in that they were created to contain only the easily determined identification data, dry density, water content, confining pressure and compaction energy. As earlier noted, no distinction has been made between the two rollers used in these studies. The energy imparted by each has been calculated accounting for the roller features and it is this energy which is used in the relations.

Section 4

DESIGN ENGINEERING

This option is associated with the case of borrow soil known in advance of construction. It is intended for use in design. Its purpose is the creation of the compaction specification that will assure the presence of desired selected behaviour parameters. Figure 4.1 is the flow chart to guide one through the procedure.

Let us assume the borrow has been identified and the soil, by test, found to belong to one of the categories of soils in this study. The engineer then selects the charts that apply to that soil category and which contain the behaviour parameters that are of concern to the design. For each behaviour parameter the engineer selects the magnitude of the parameter that is desired. On the charts this becomes the minimum expected value for most parameters (or the maximum expected value for volume change caused by soaking). The chart will provide the mean water content, the half range of water content variability and compaction energy or dry density that will produce that desired value with assurance. For any given parameter several different sets of compaction variables may be possible. This procedure is repeated for each behaviour parameter of concern.

If the range of compaction variables is not

satisfactory to the engineer, the option exists to change the desired selected behaviour parameters and/or concentrate the requirements only upon the "most important" parameters. The engineer can change the suite of parameters or compaction variables until there is produced that set of behaviour considered "optimum". This requires the use of the engineer´s judgement.

This study clearly shows that close control of the water content and the half-range variability of the water content at time of compaction can improve markedly the magnitudes of the behaviour parameters. Such trade-off choices can be preformed in advance of construction, in the design office on paper. This provides the engineer with a much larger degree of control over the behaviour of the earthwork in his project.

4.2 A Design Engineering Example

Let us assume the soil to be used for an embankment has $I_p = 9\ \%$ and it is desired to have a minimum assured strength of 125 kPa (18.13 psi) and maximum $\frac{\Delta V}{V_o}$ of 0.35 % at a point in the embankment where (vertical) confinement is 70 kPa (10.15 psi). What compaction specification will yield these criteria with assurance ?

If the roller will be a Caterpillar 825, then the charts of this study are usable.

Use Figures 4.5, 4.9 and 4.11 to obtain candidate sets of compaction variables for each desired parameter at a time.

Table 4.1

For a desired minimum strength of 125 kPa

minimum	mean		
q_c	W_c	$V_{(w)}$	P_c
135.0	14.0	1.5	600.0-1200.0
130.0	13.0	3.0	600.0-1200.0
128.0	15.0	1.5	600.0-1200.0

Table 4.2

For a desired maximum volume change of 0.35 %

maximum $\frac{\Delta V}{V_o}$ (%)	mean W_c	$V_{(w)}$	P_c
0.350	19.43	1.5	900.0
0.350	17.47	3.0	900.0
0.350	19.35	1.5	1200.0
0.325	13.00	3.0	1200.0

The data in Table 4.2 indicate that the desired maximum magnitude for volume change can be controlled by a number of different suites of Compaction variables. the designer must apply his judgement as to where the best trade-off lies. For example, a lesser average water content can create the criterion at a larger tolerable range of water content on the lift. The judgement will involve whether water control can be accomplished or whether it is better to apply more compaction energy without as stringent regulation of water. In addition, the trade-off must include the other criteria that were set by the designer. Indeed, these data allow more quantitative control, but require more judgement in the process. In the data of Table 4.2 it appears that the criterion can be controlled nicely at a mean W_c =13.0,

$V_{(w)} = 3.0$ and $P_c = 1200.0$. Table 3.1 indicates that $P_c = 1200.0$ will be created by this roller with 3 passes at 3 mph.

It must be realized that it is difficult to find compaction variables that will assure the exact criteria selected by the engineer. In such a case, the designer must decide whether,

1) the criteria can be changed for one or more behaviour parameters;
2) the limits placed upon the allowable variability of water content in the embankment can be changed; or
3) some criteria for behaviour parameters can be considered unnecessary.

In making these selections the engineer uses judgement and experience about the manner in which the project will be affected by these changes.

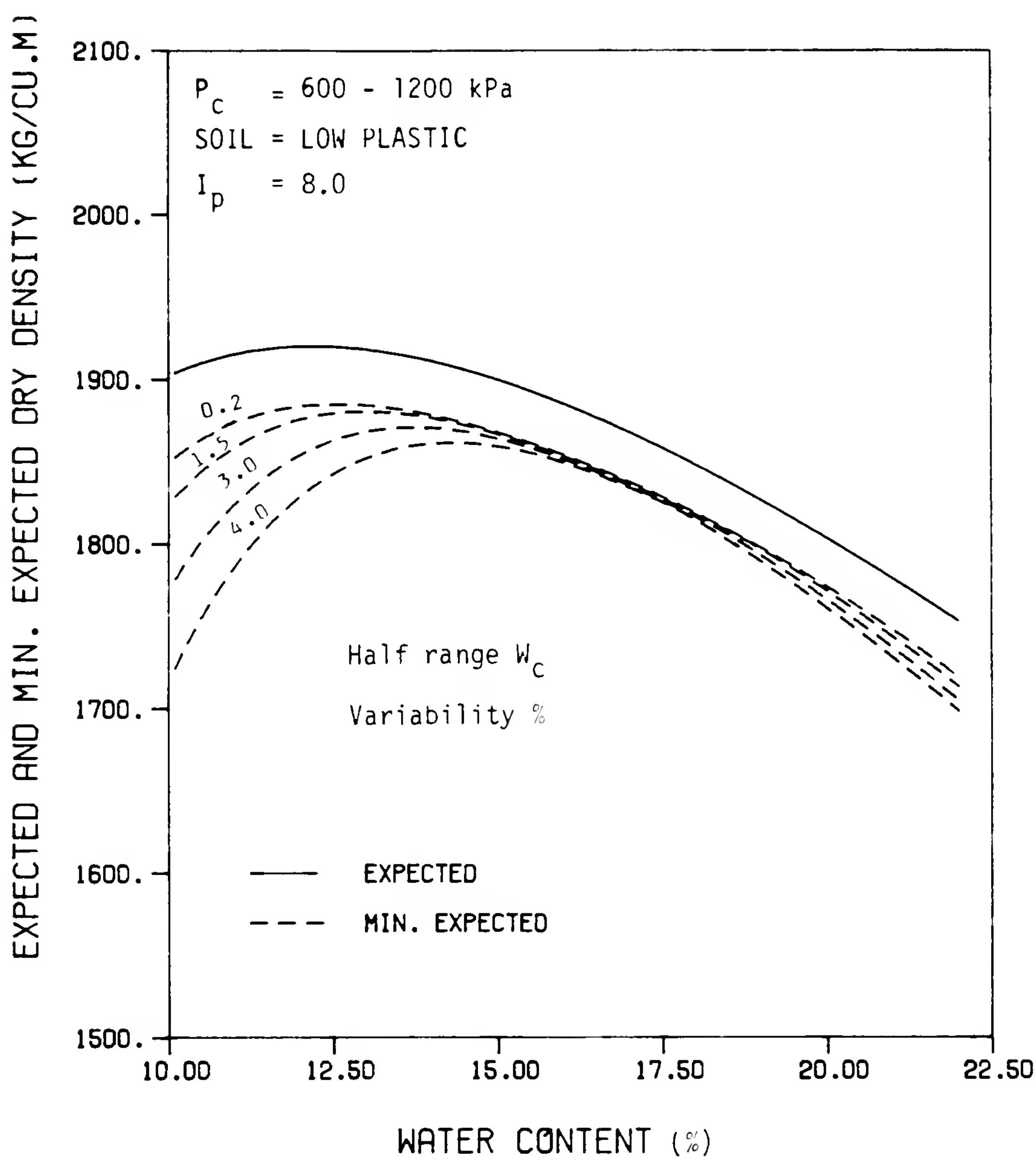

Figure 4.2 Design Chart for Field Dry Density

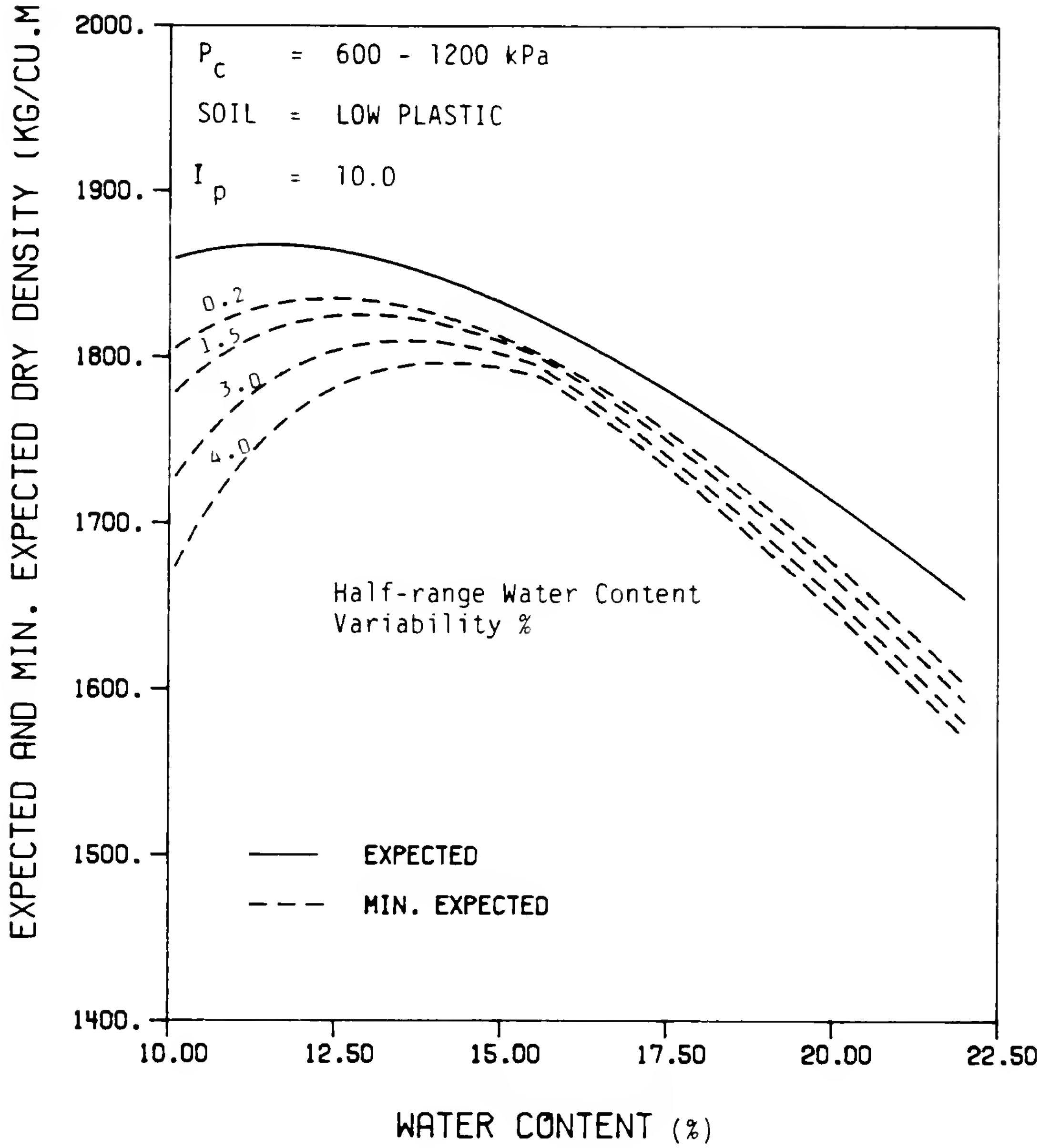

Figure 4.3 Design Chart for Field Dry Density

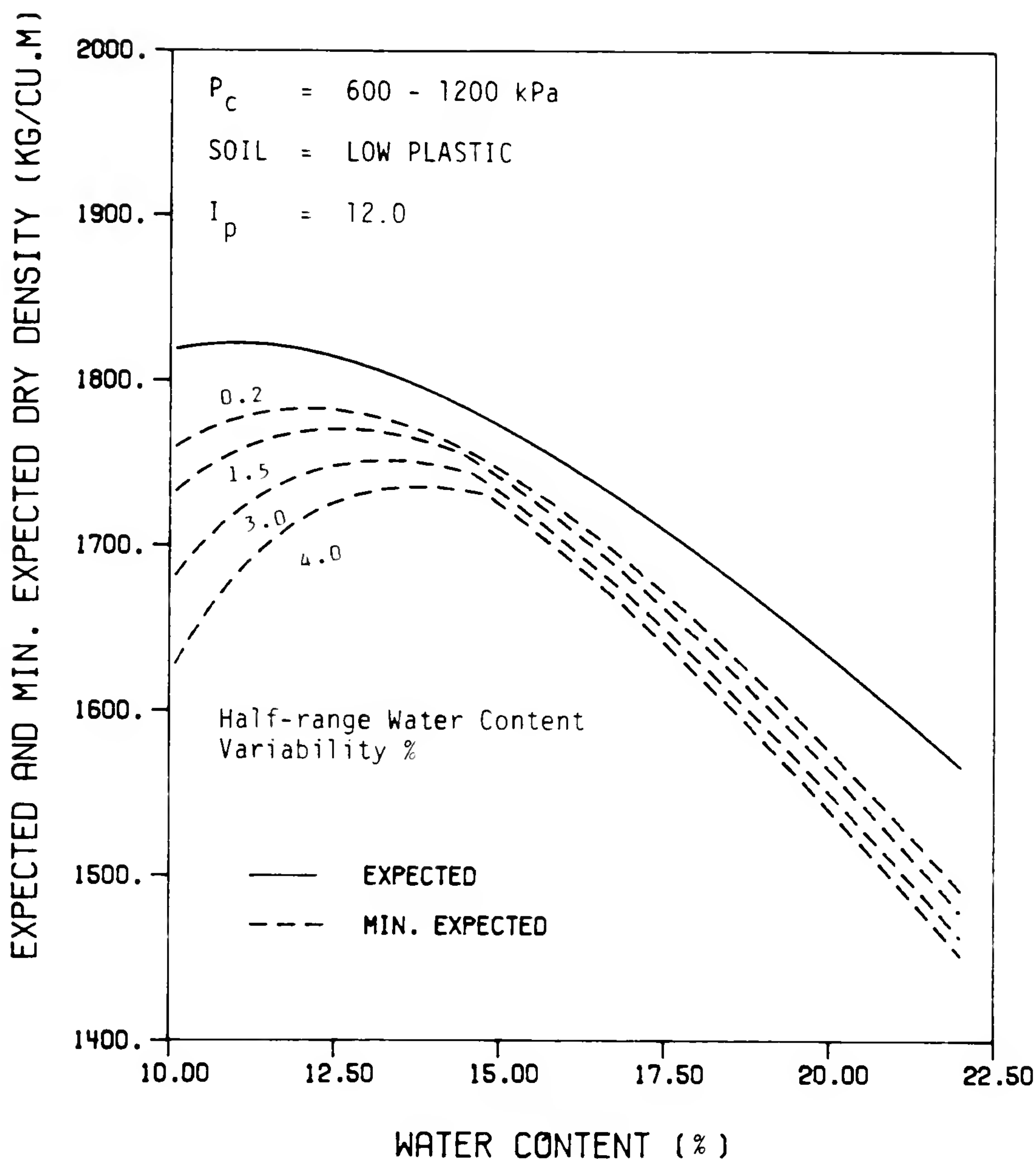

Figure 4.4 Design Chart for Field Dry Density

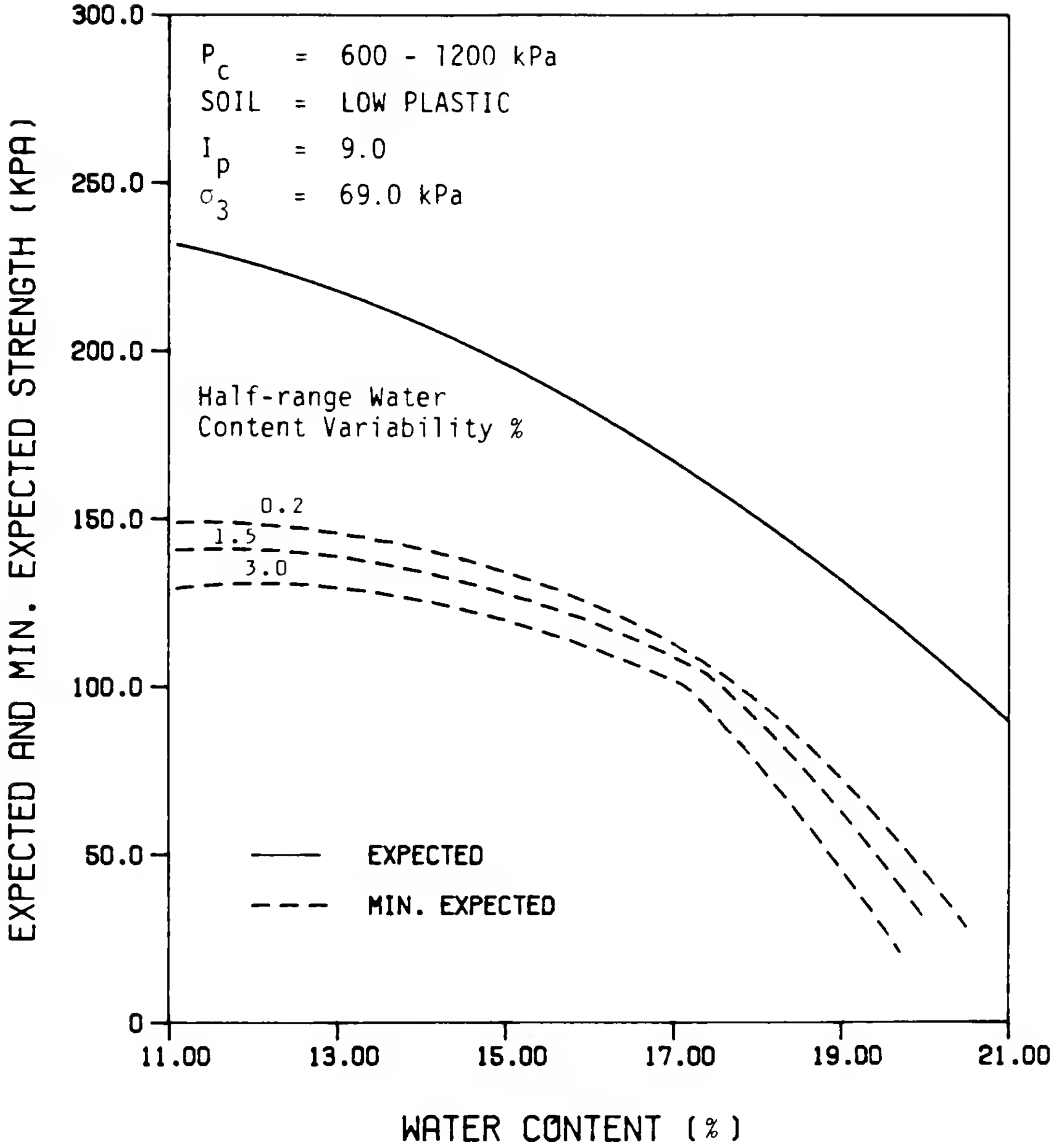

Figure 4.5 Design Chart for Field Confined Undrained Strength $\left[\left(\frac{\sigma_1-\sigma_3}{2}\right)_f\right]$

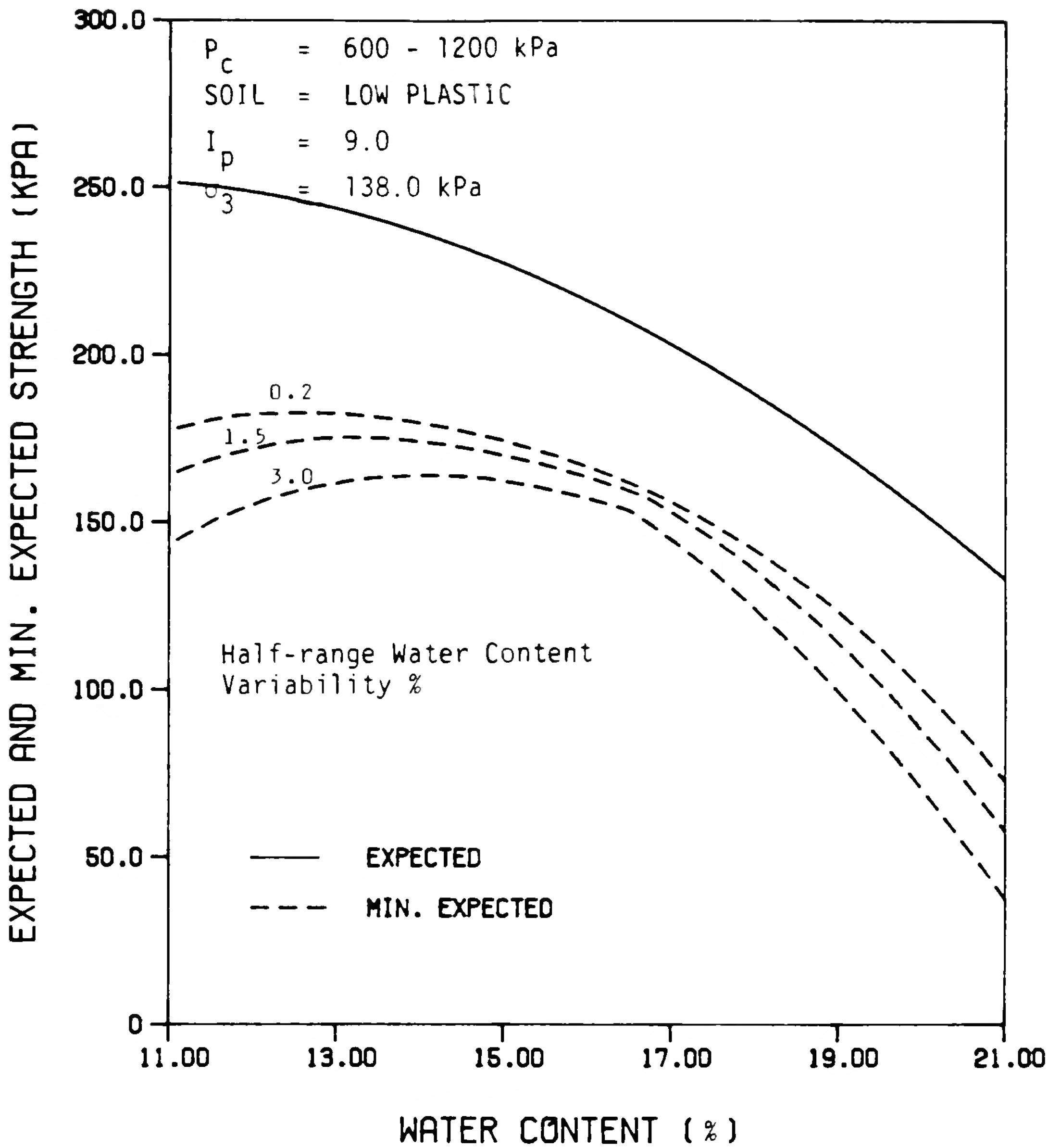

Figure 4.6 Design Chart for Field Confined Undrained Strength $\left[\left(\frac{\sigma_1-\sigma_3}{2}\right)_f\right]$

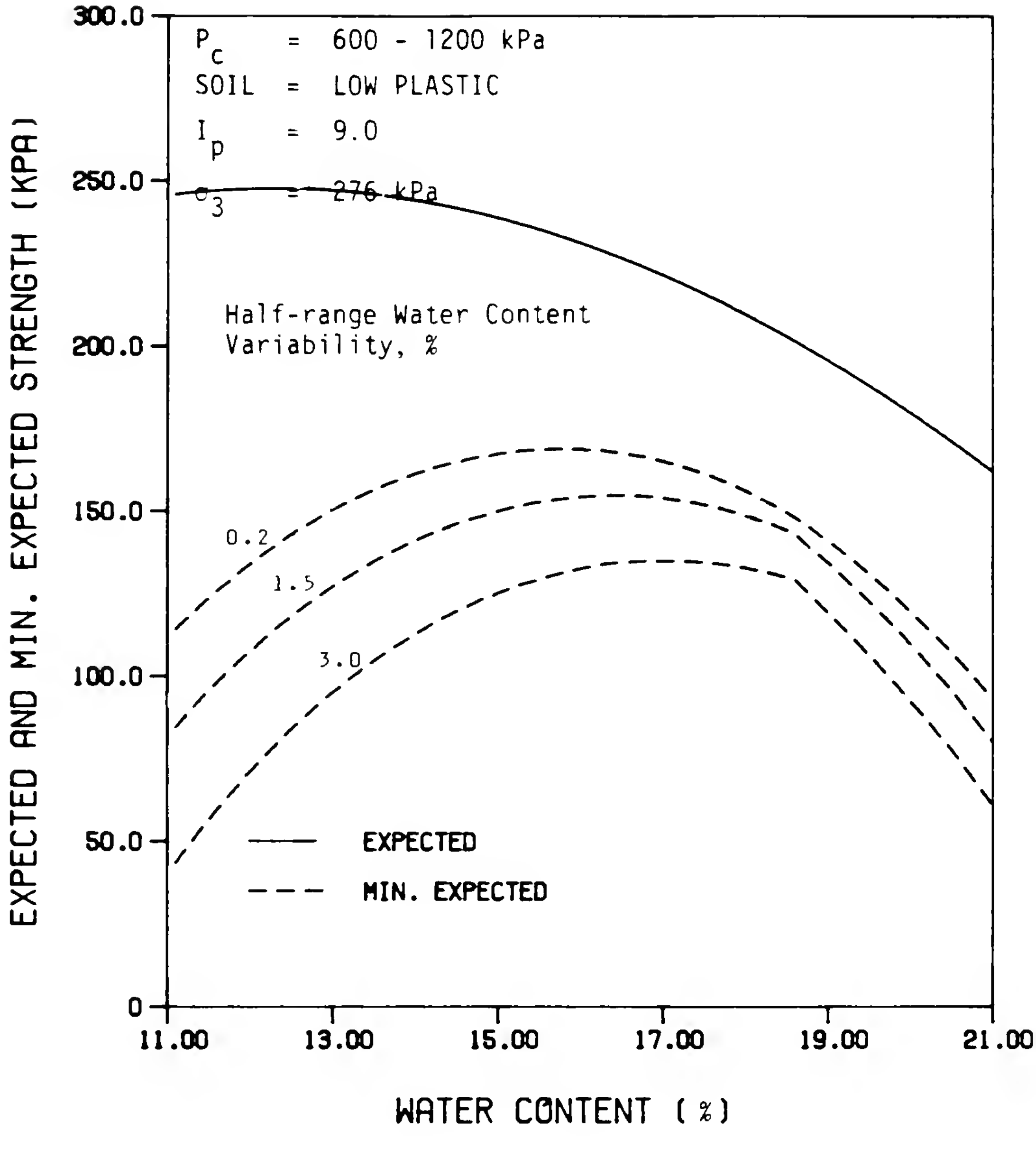

Figure 4.7 Design Chart for Field Confined Undrained Strength $\left[\left(\frac{\sigma_1-\sigma_3}{2}\right)_f\right]$

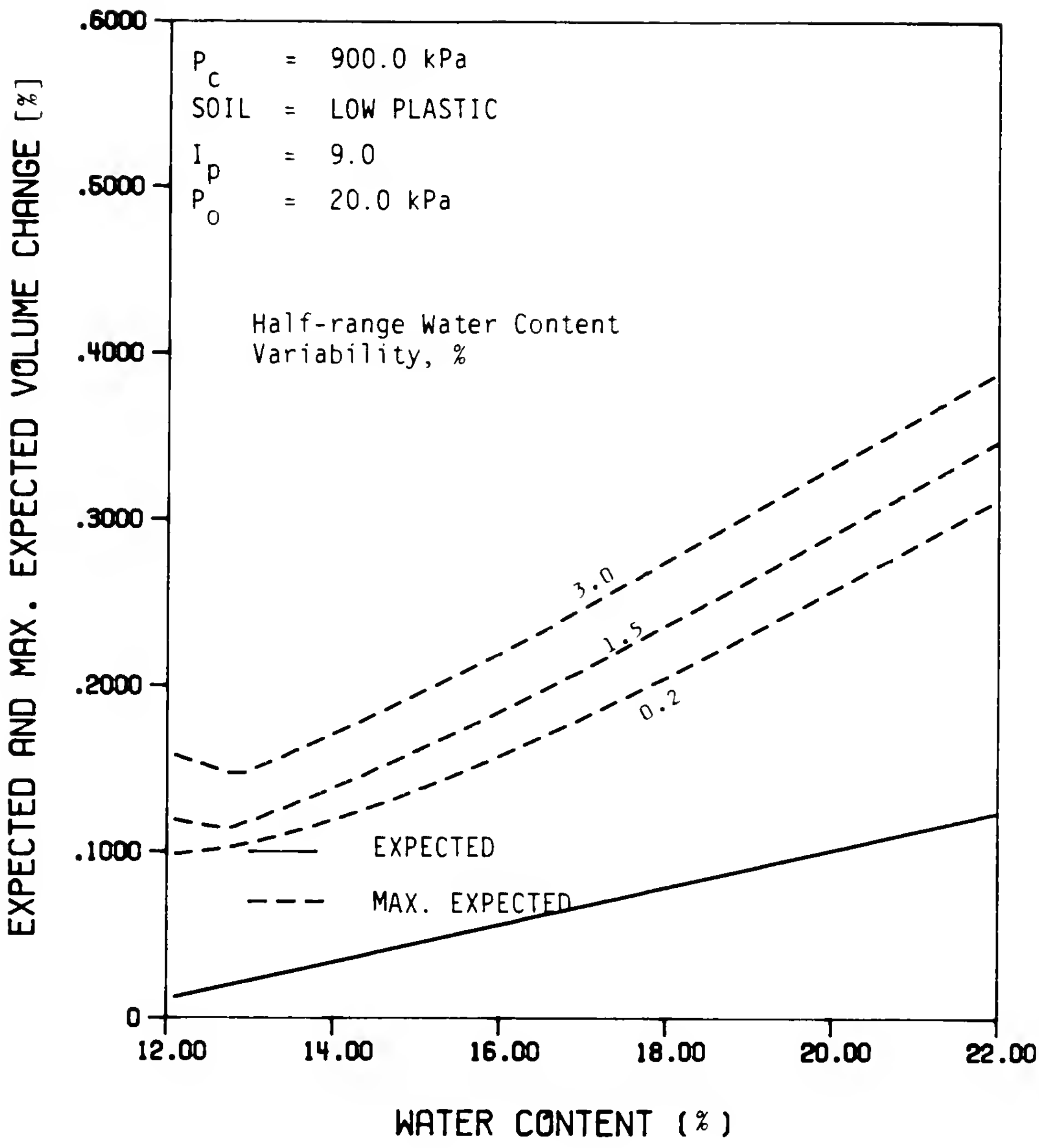

Figure 4.8 Design Chart for Field 1-D Volume Change on Soaking

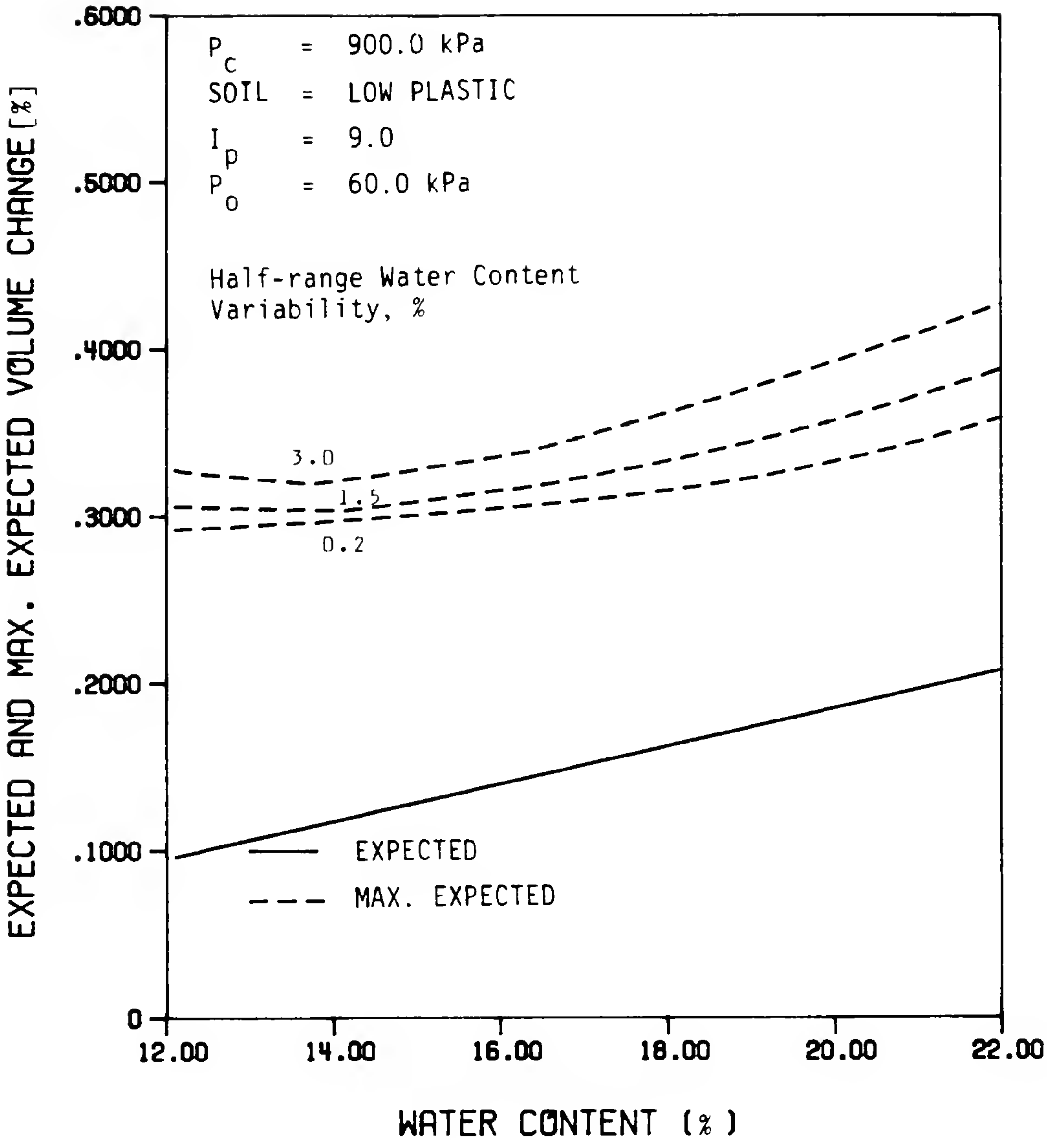

Figure 4.9 Design Chart for Field 1-D Volume Change on Soaking

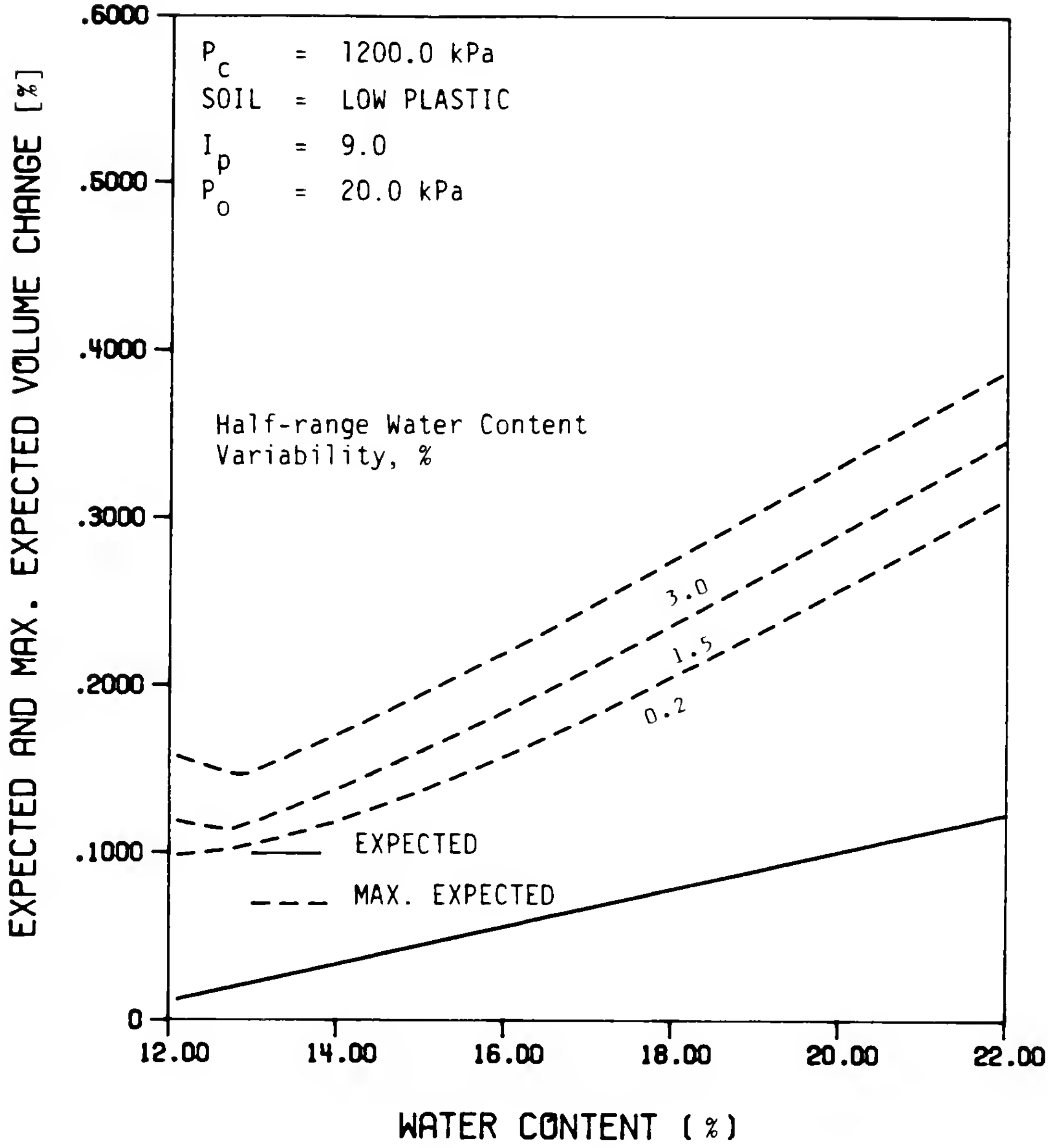

Figure 4.10 Design Chart for Field 1-D Volume Change on Soaking

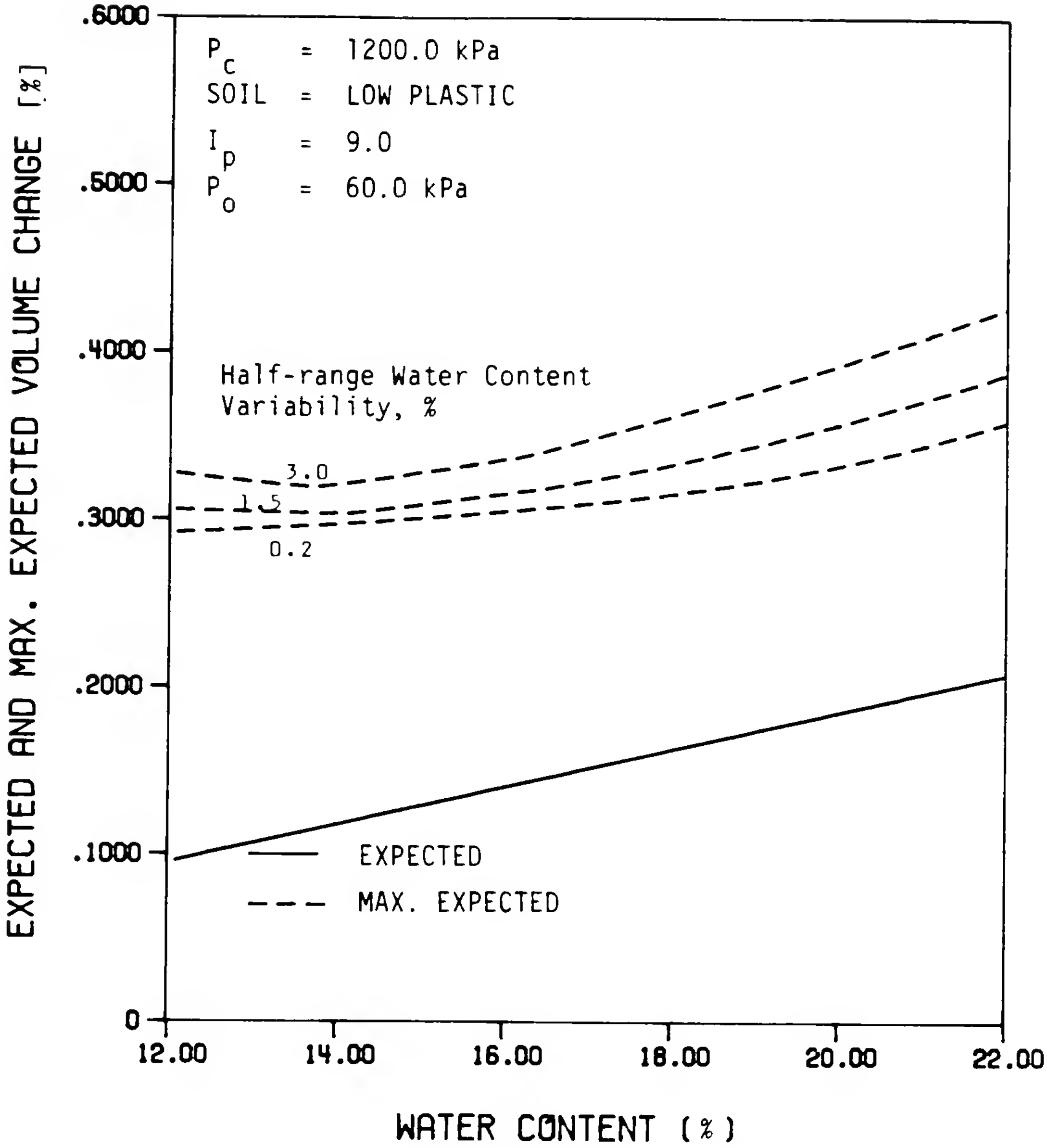

Figure 4.11 Design Chart for Field 1-D Volume Change Percentage

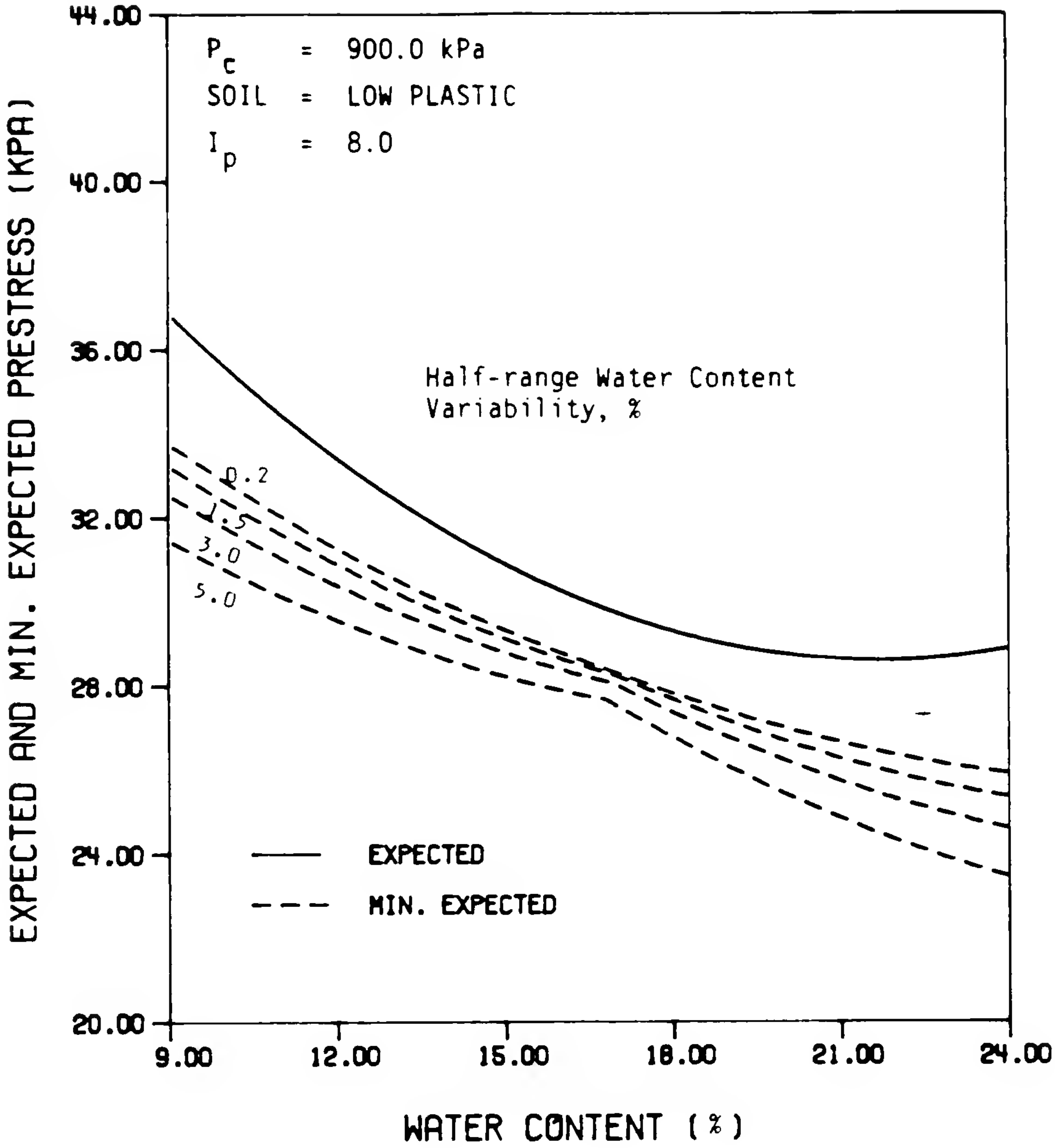

Figure 4.12 Design Chart for Field Prestress

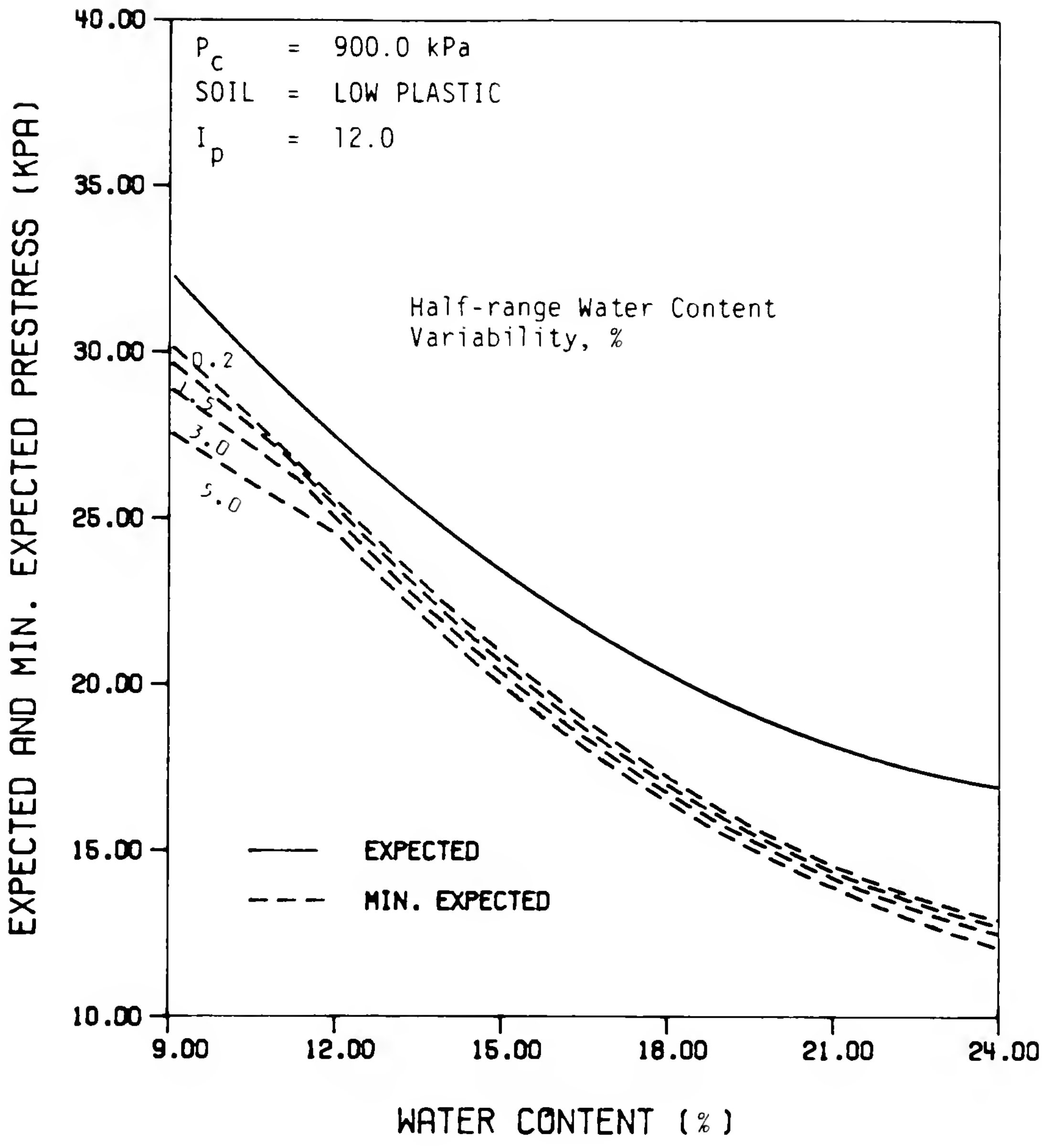

Figure 4.13 Design Chart for Field Prestress

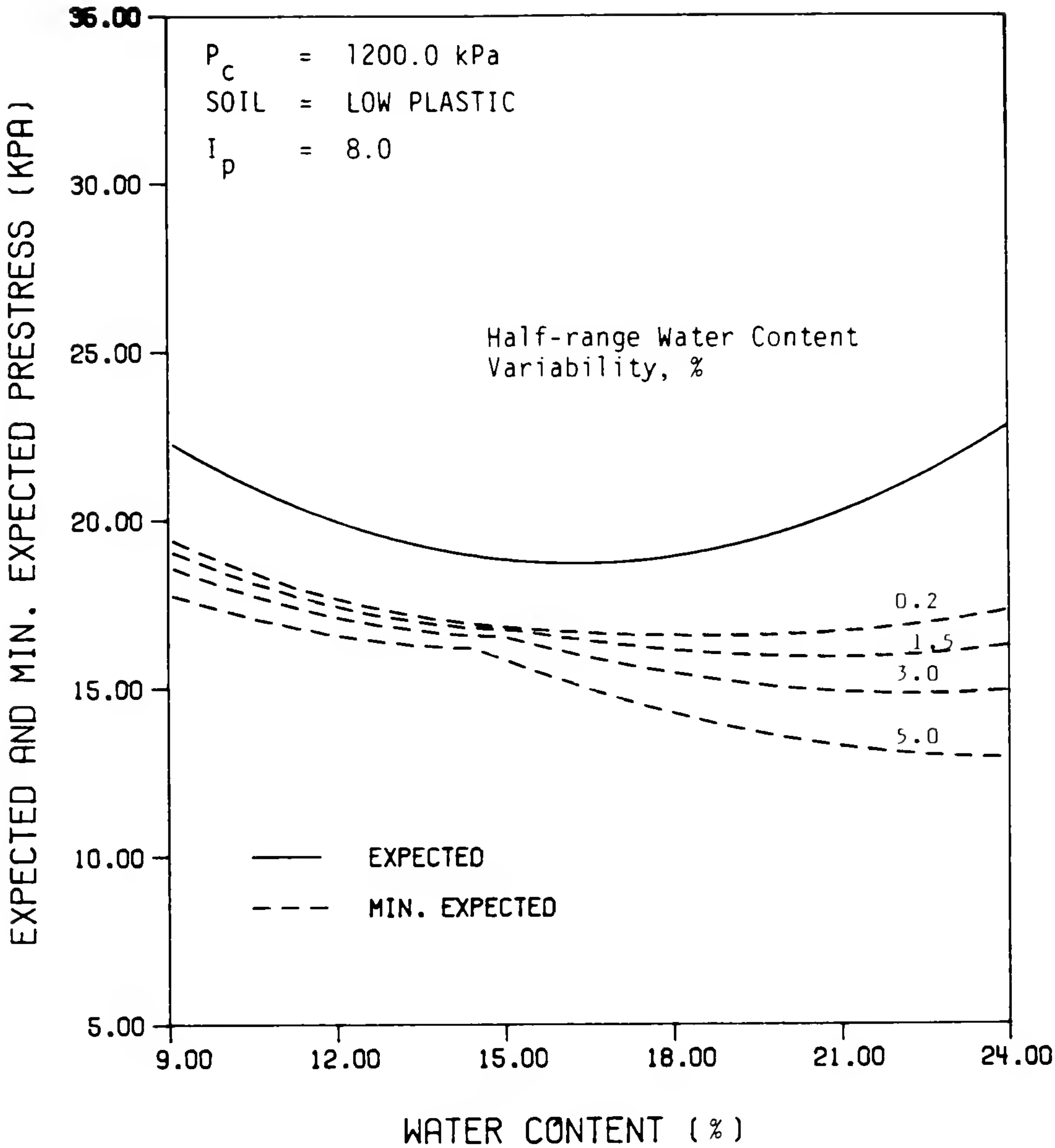

Figure 4.14 Design Chart for Field Prestress

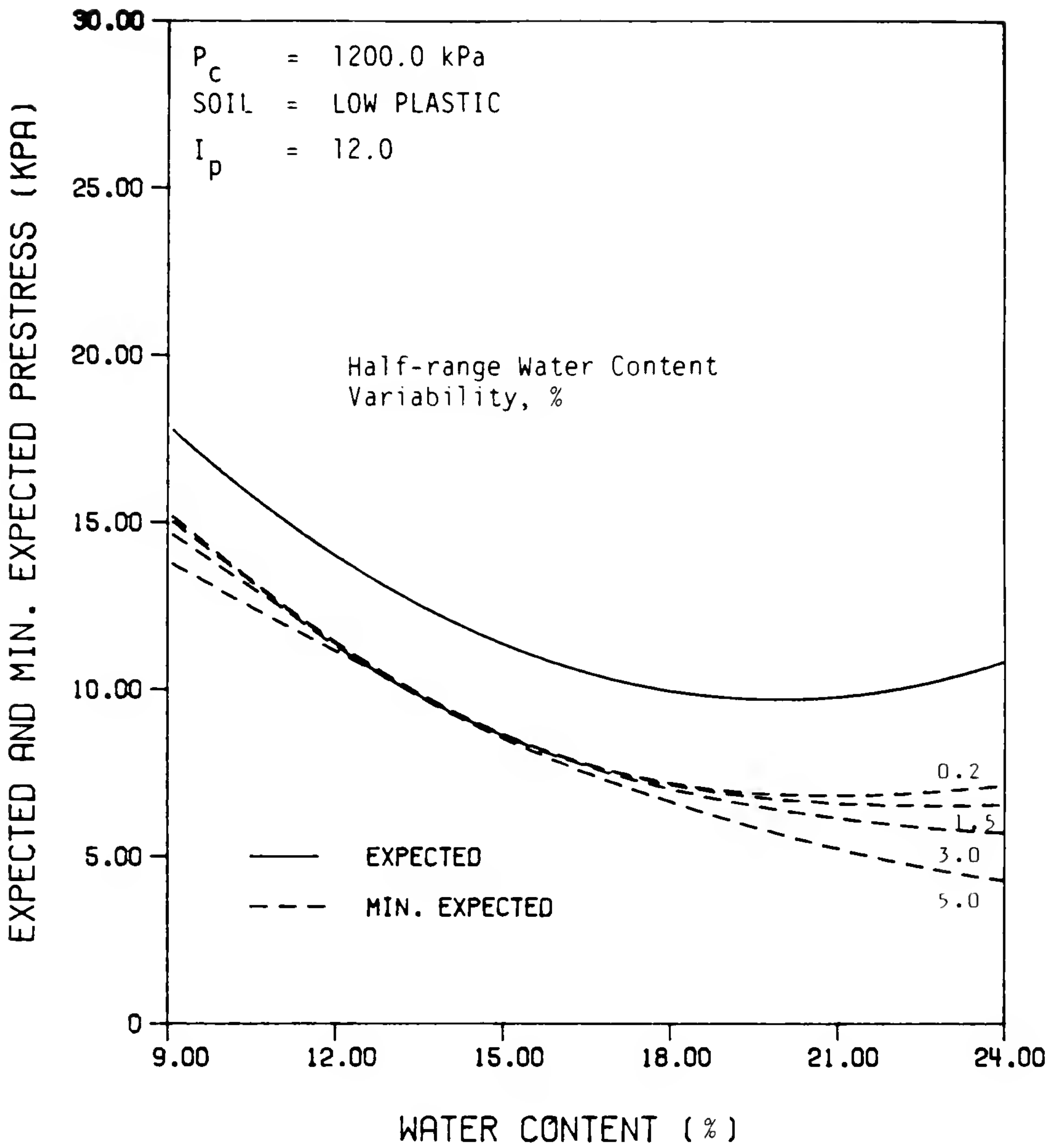

Figure 4.15 Design Chart for Field Prestress

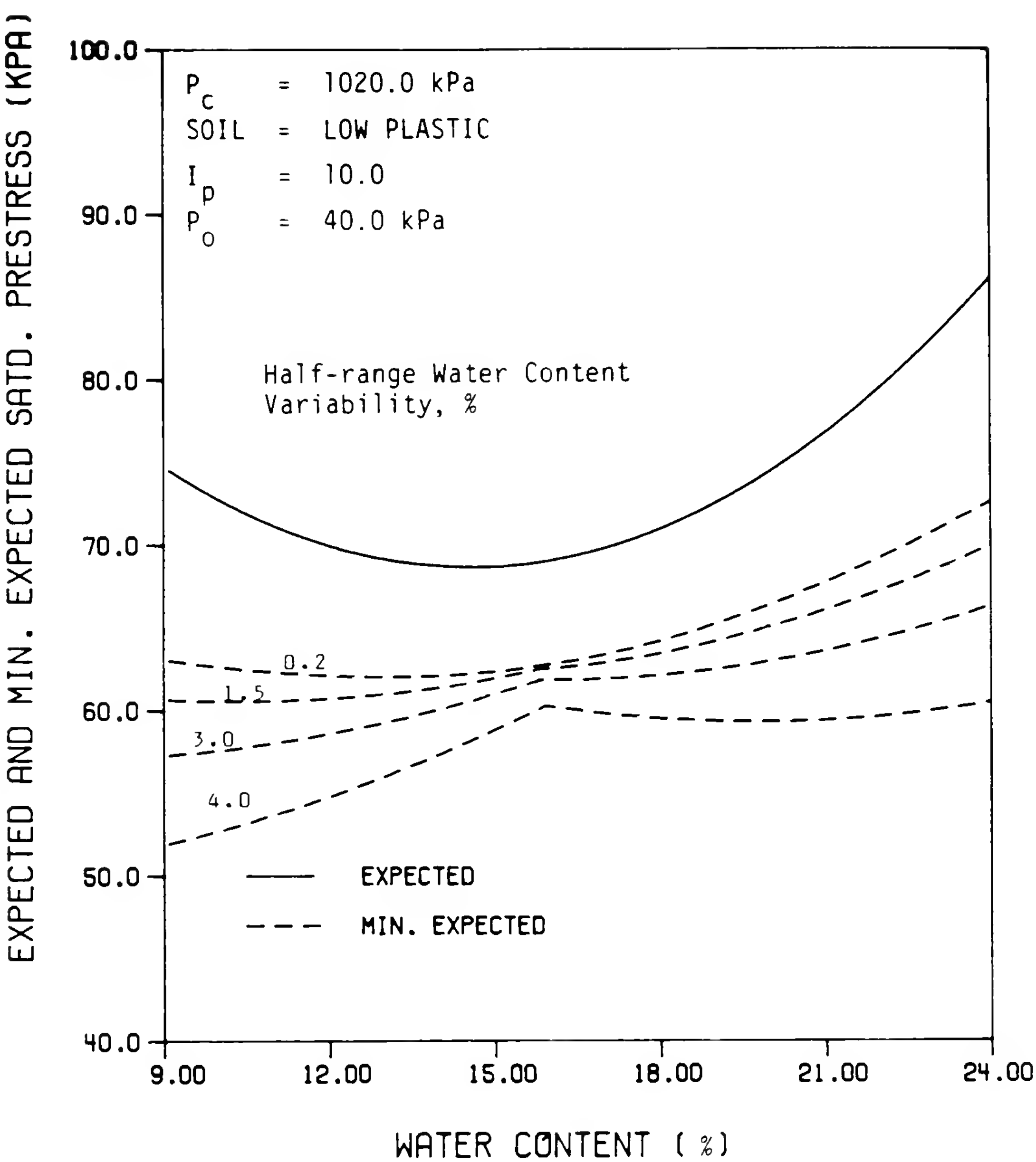

Figure 4.16 Design Chart for Field Saturated Prestress

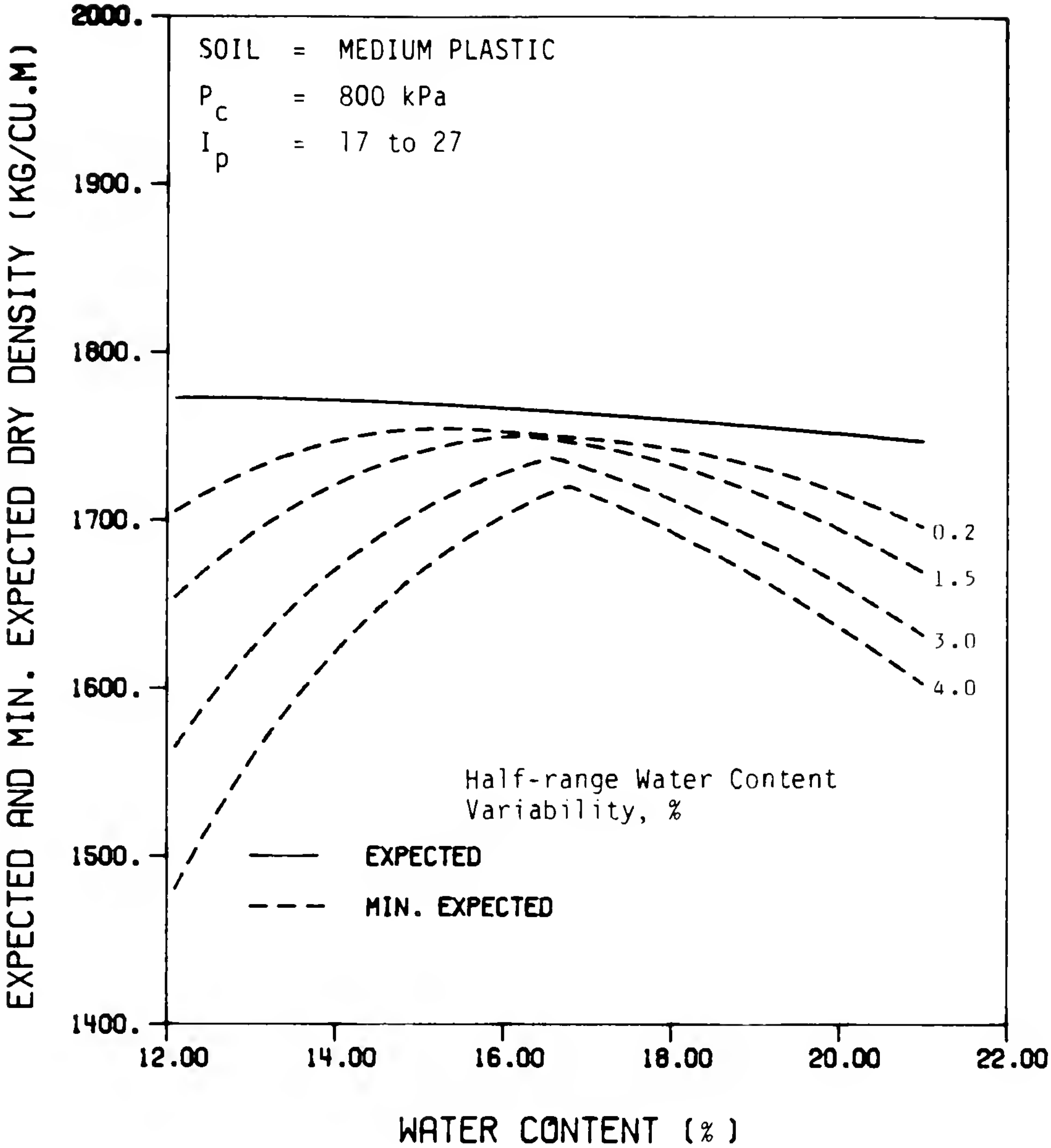

Figure 4.17 Design Chart for Field Dry Density

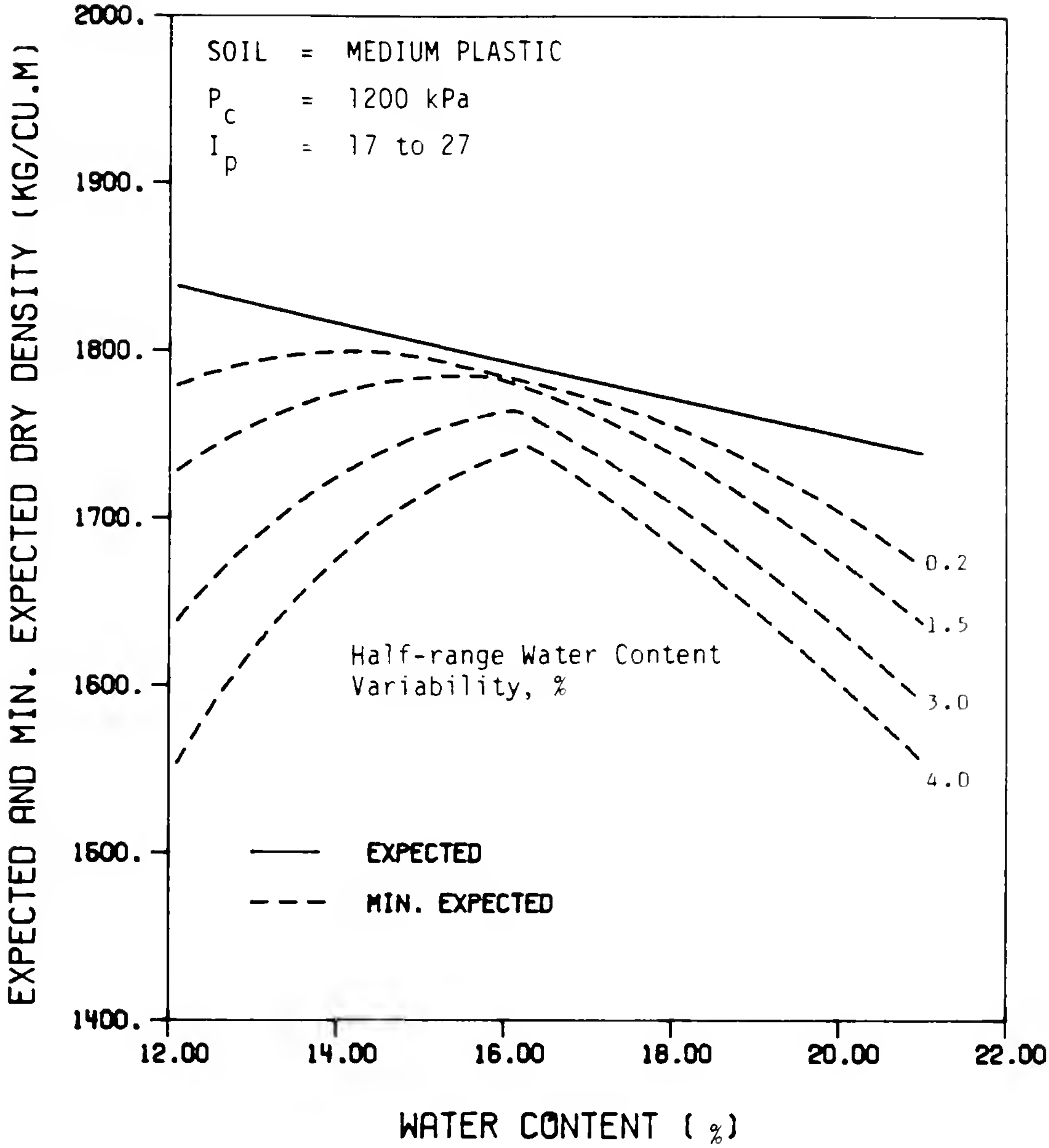

Figure 4.18 Design Chart for Field Dry Density

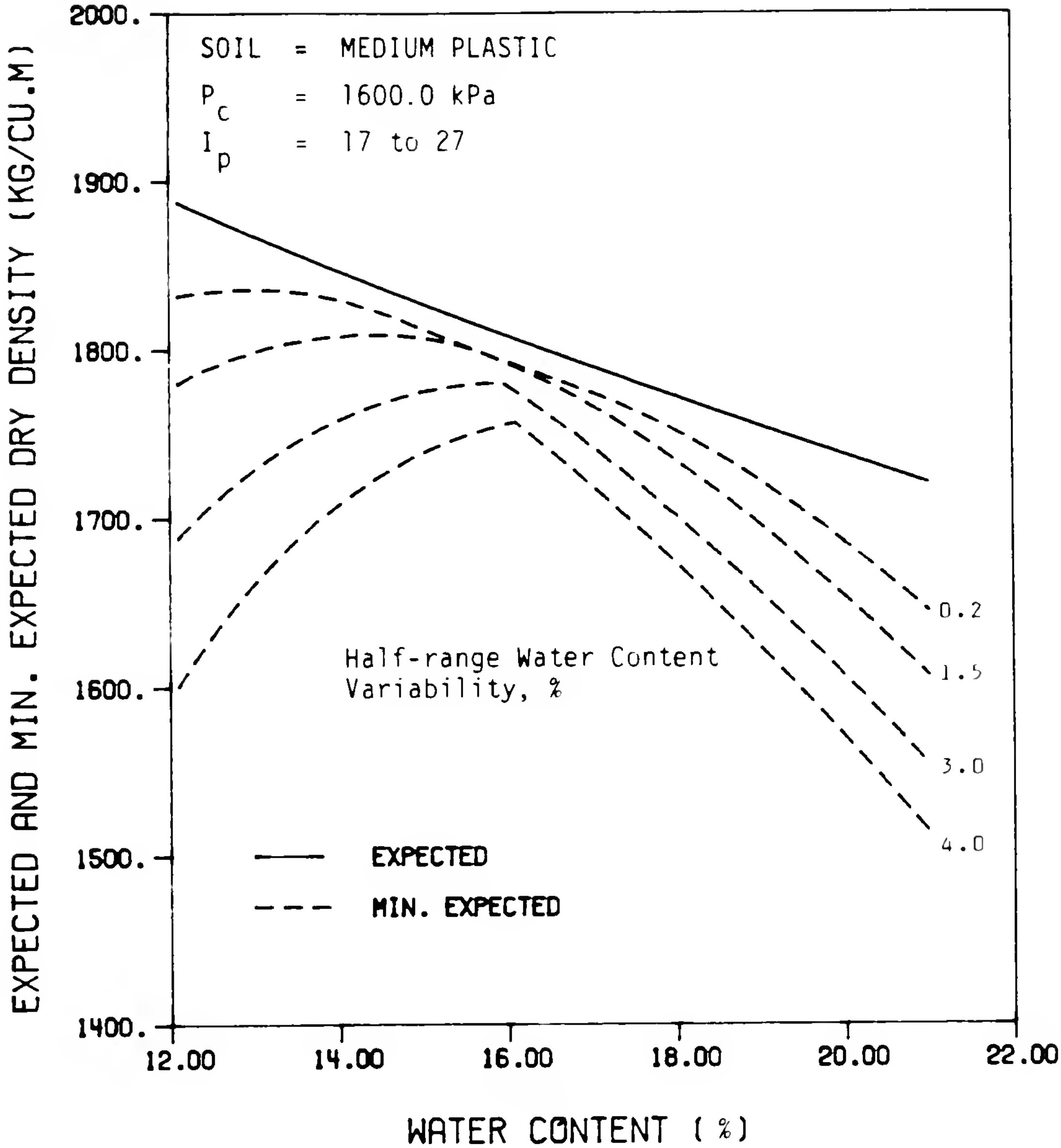

Figure 4.19 Design Chart for Field Dry Density

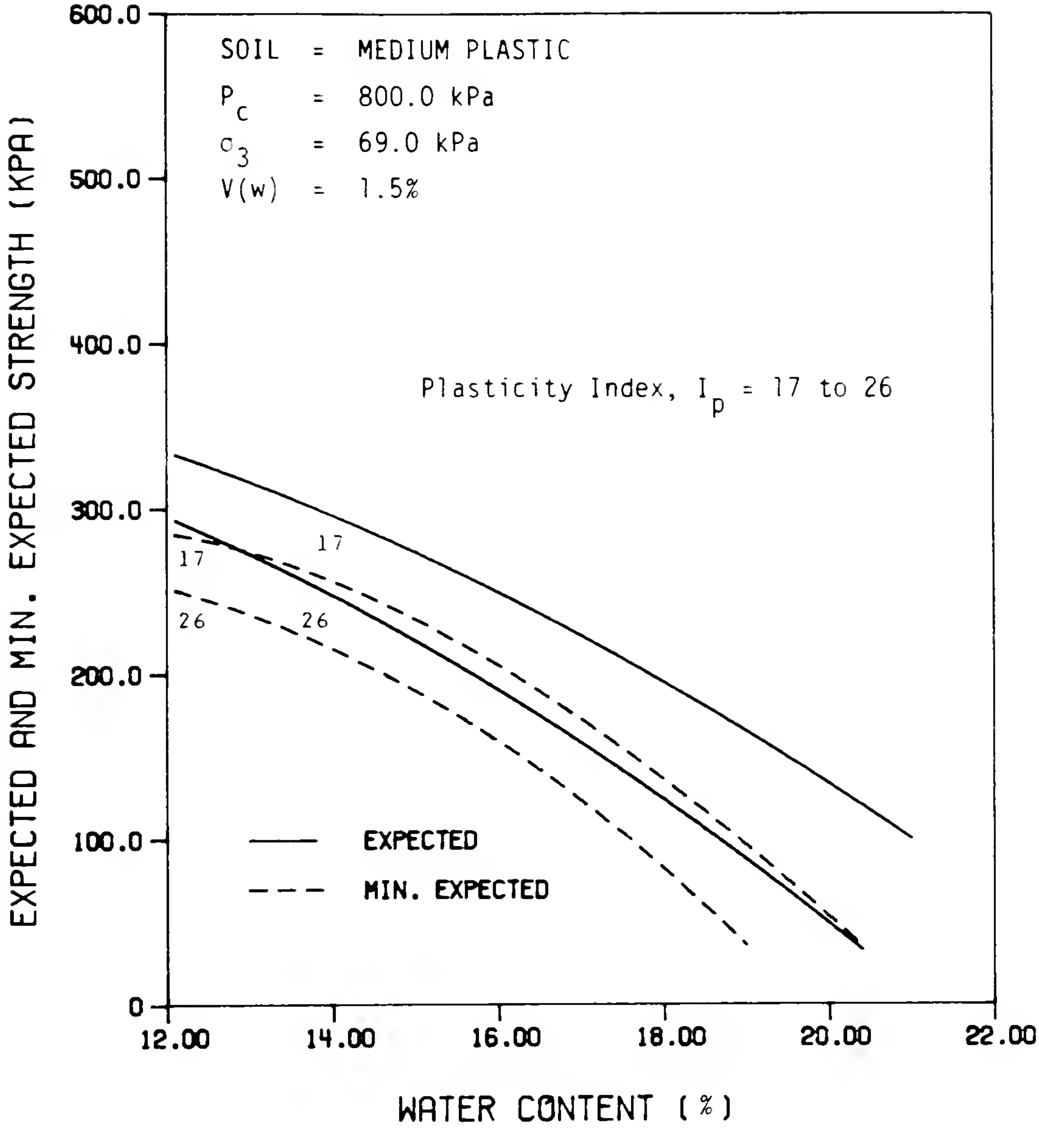

Figure 4.20 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

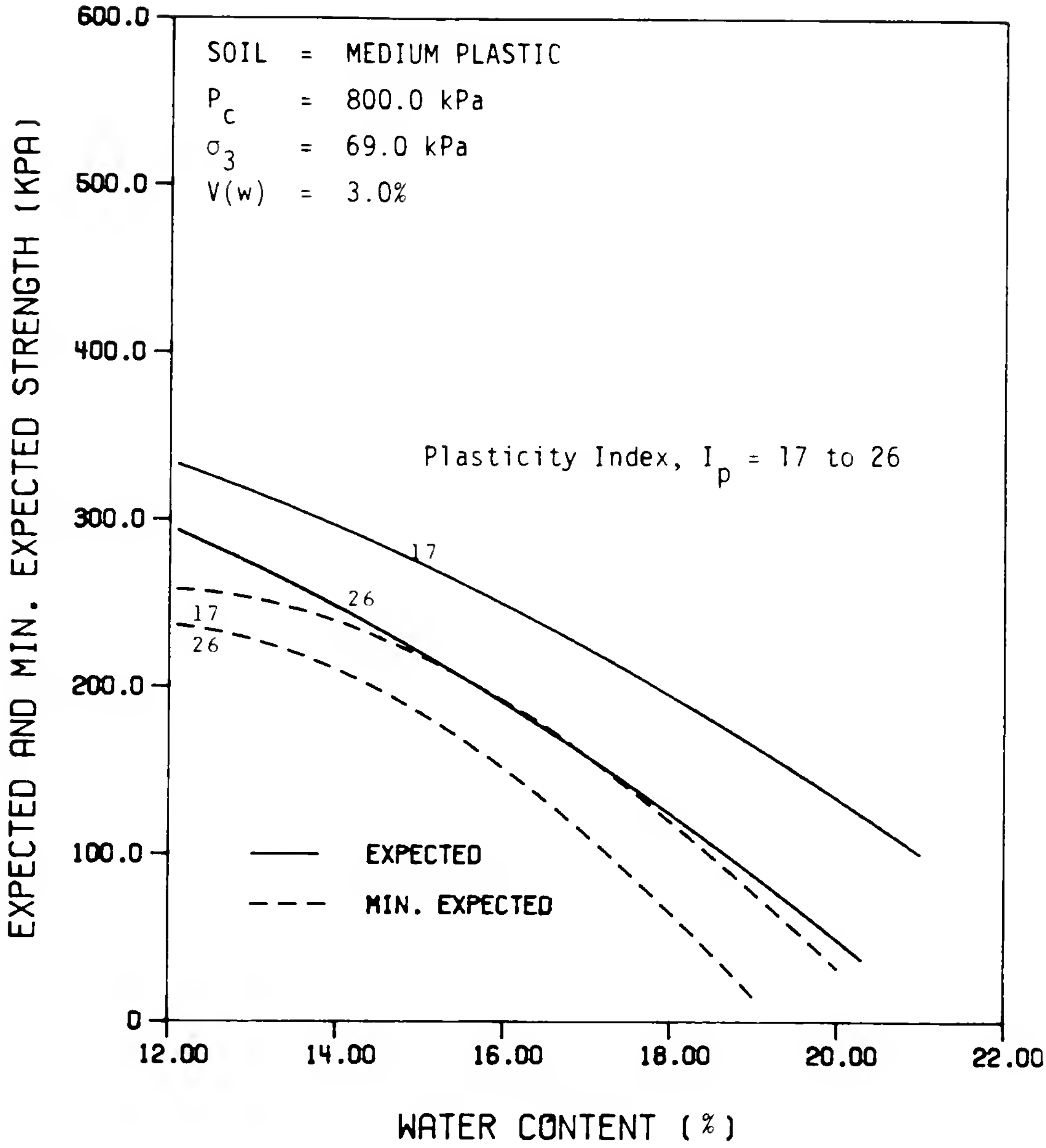

Figure 4.21 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

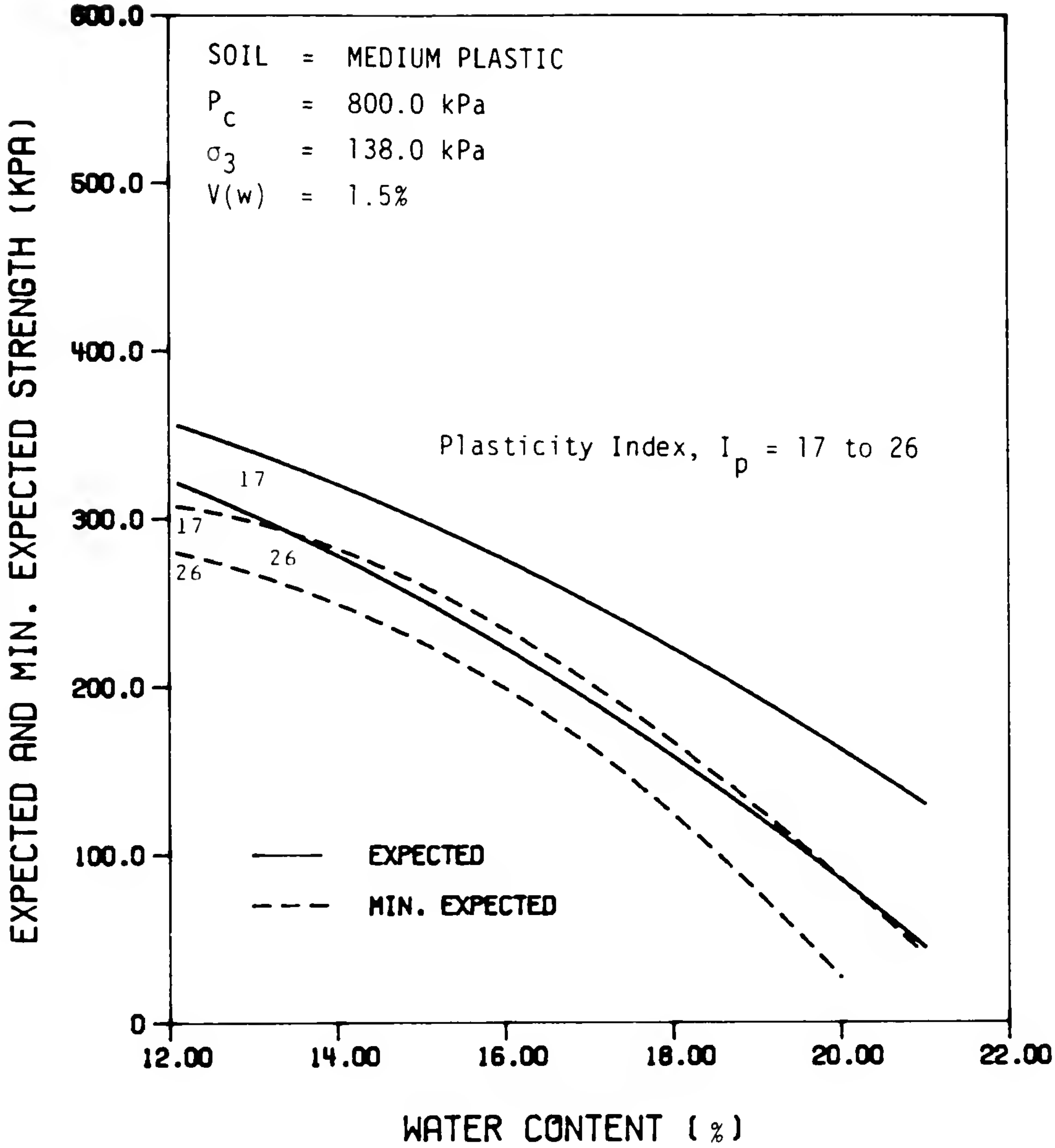

Figure 4.22 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

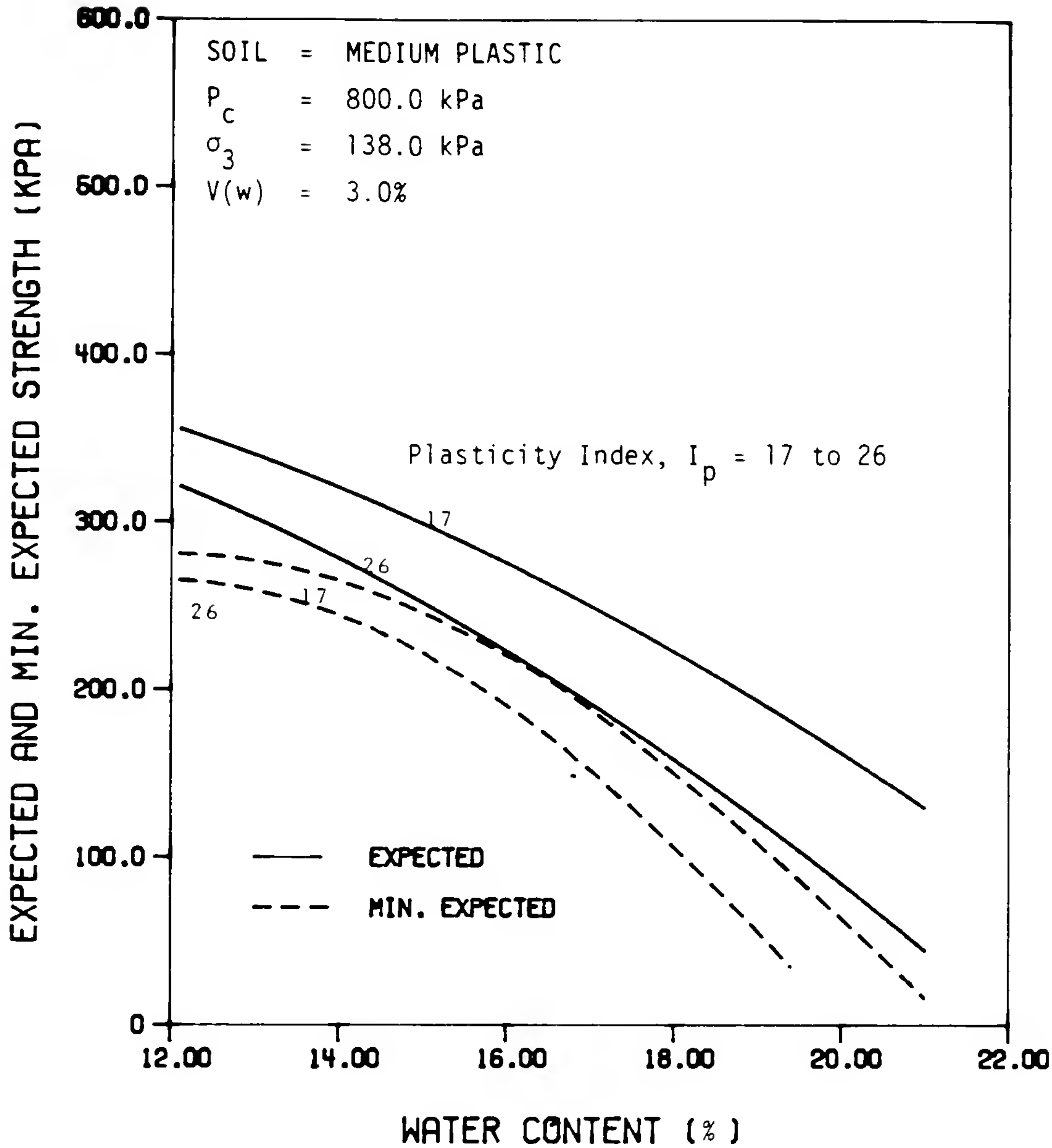

Figure 4.23 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

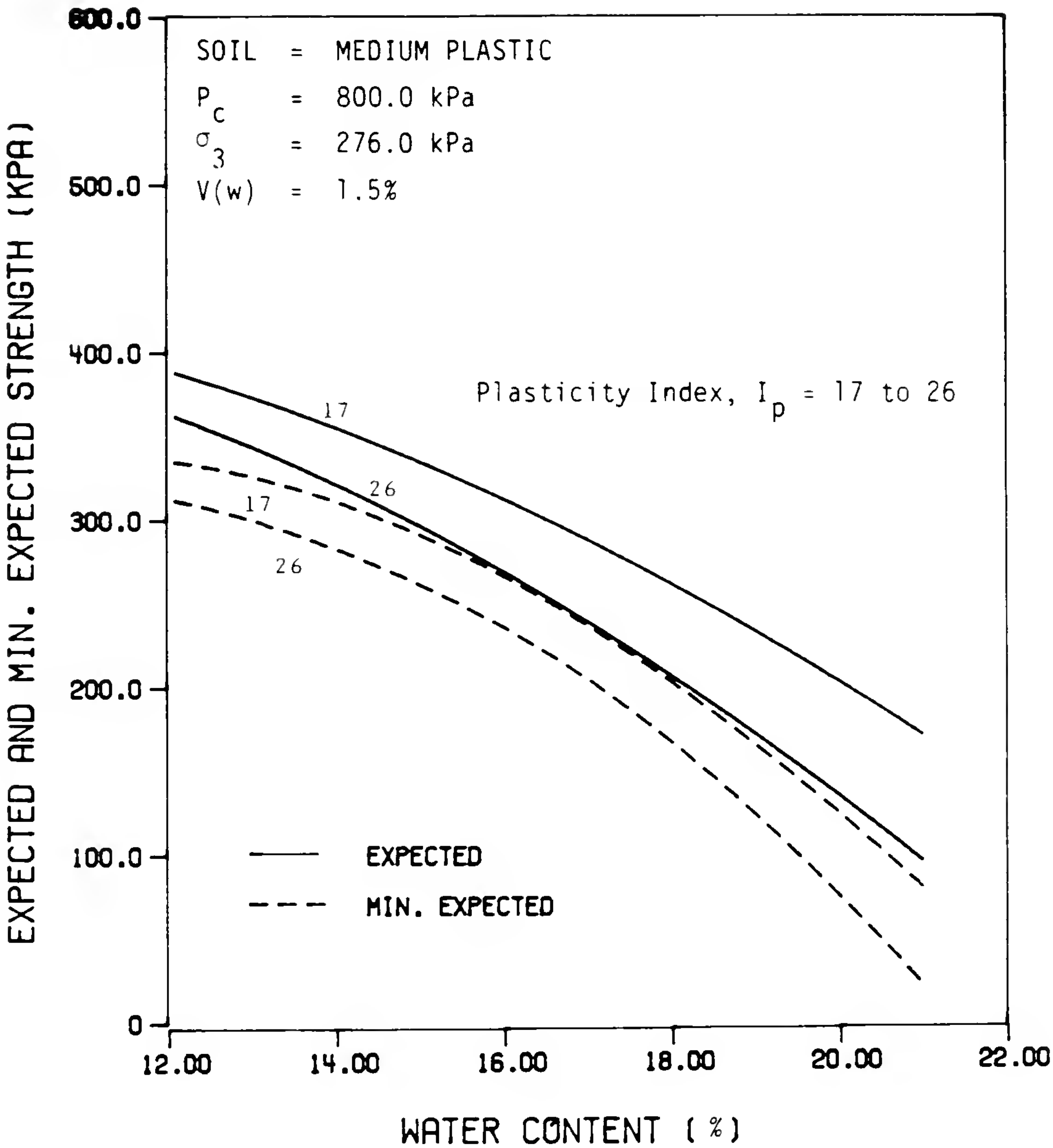

Figure 4.24 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

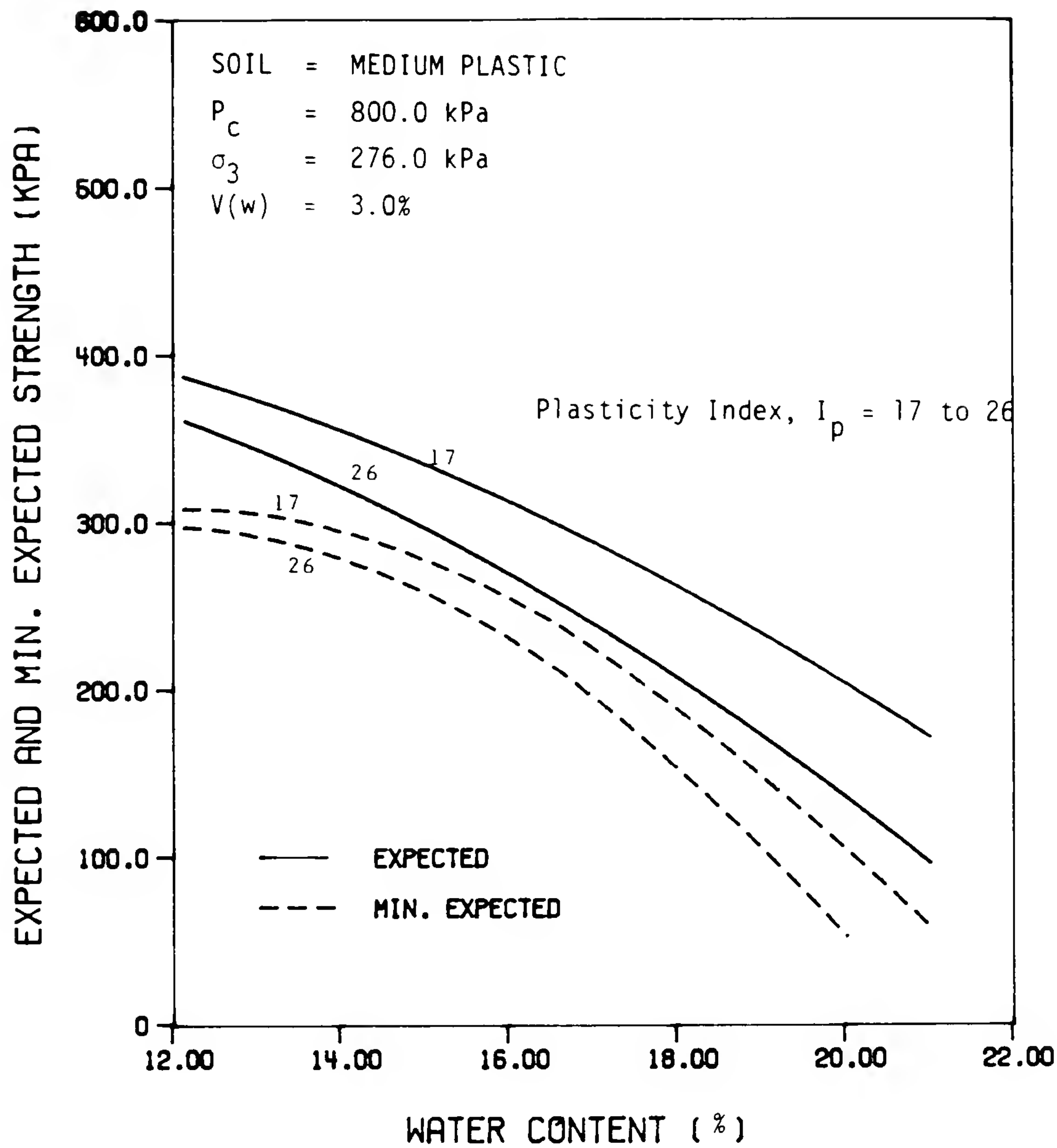

Figure 4.25 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1 - \sigma_3}{2}\right)_f$

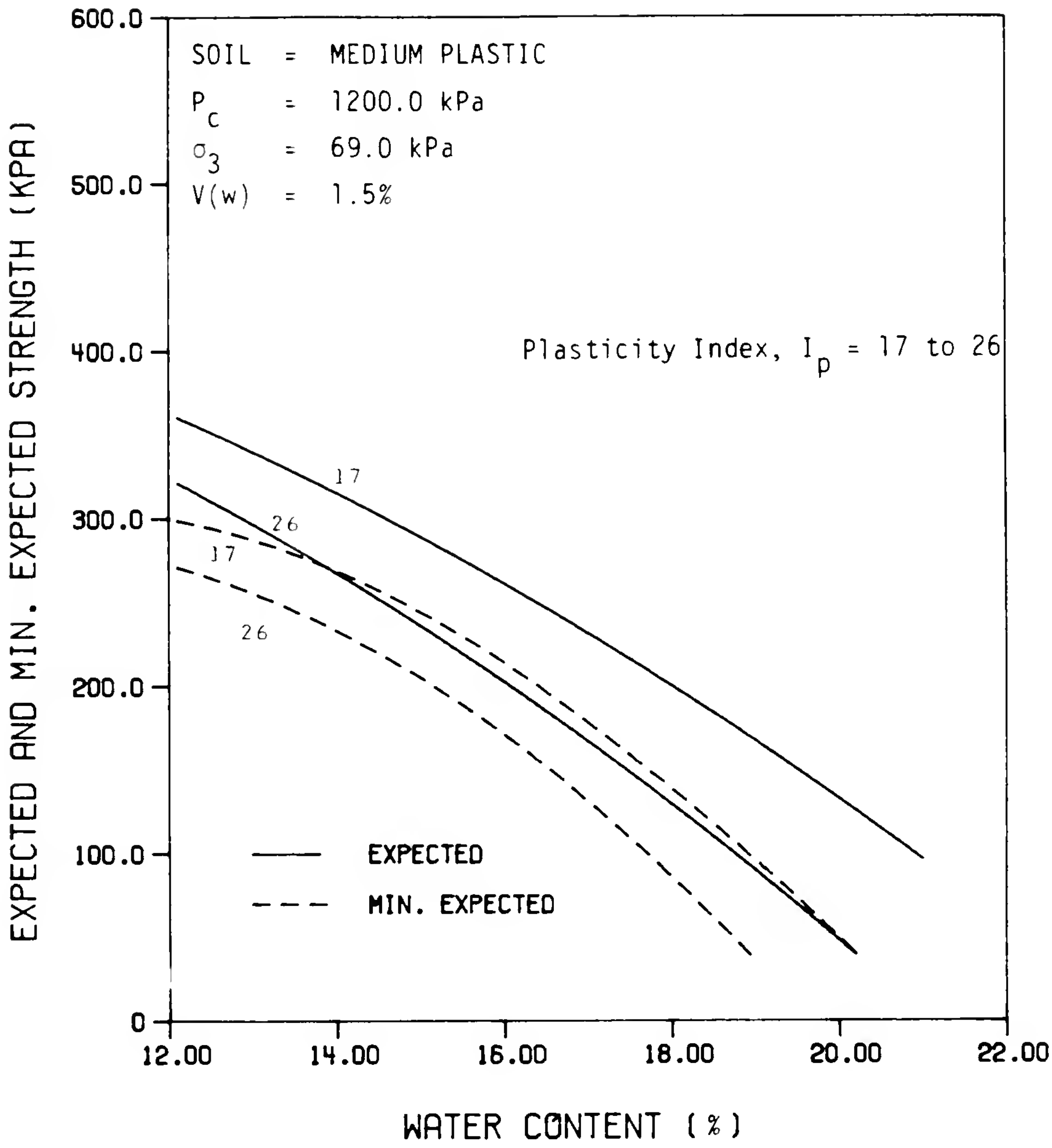

Figure 4.26 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

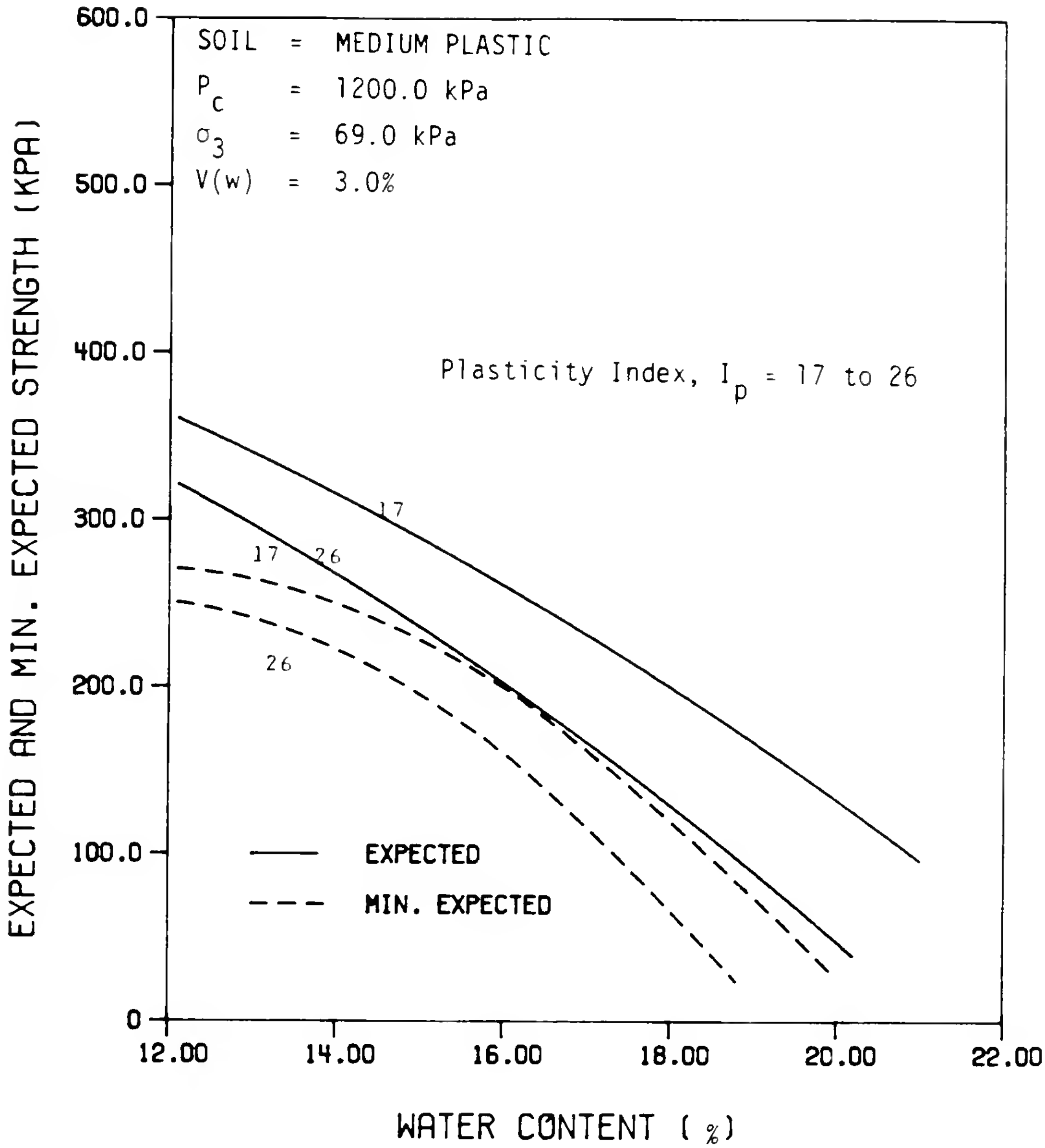

Figure 4.27 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

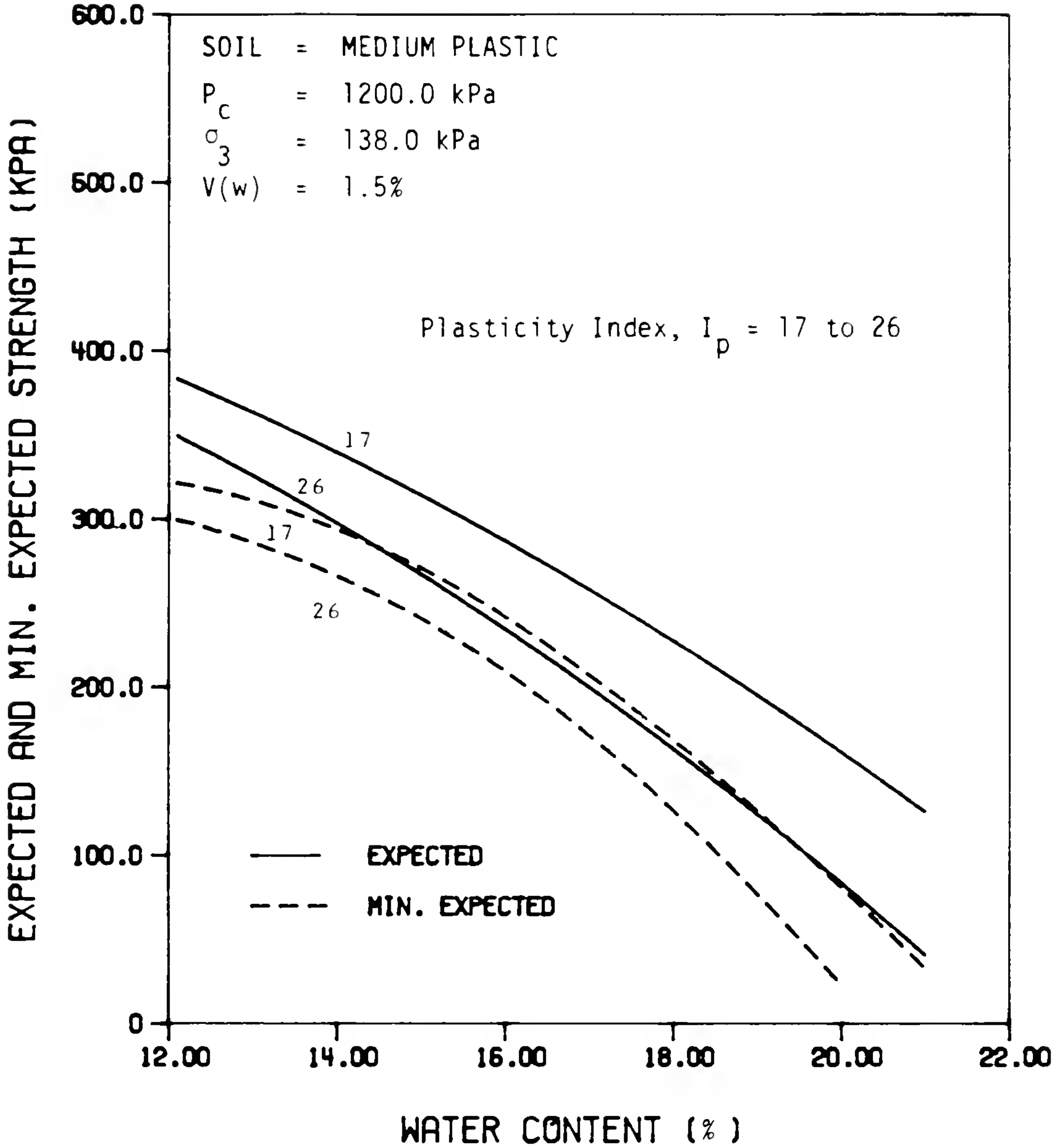

Figure 4.28 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

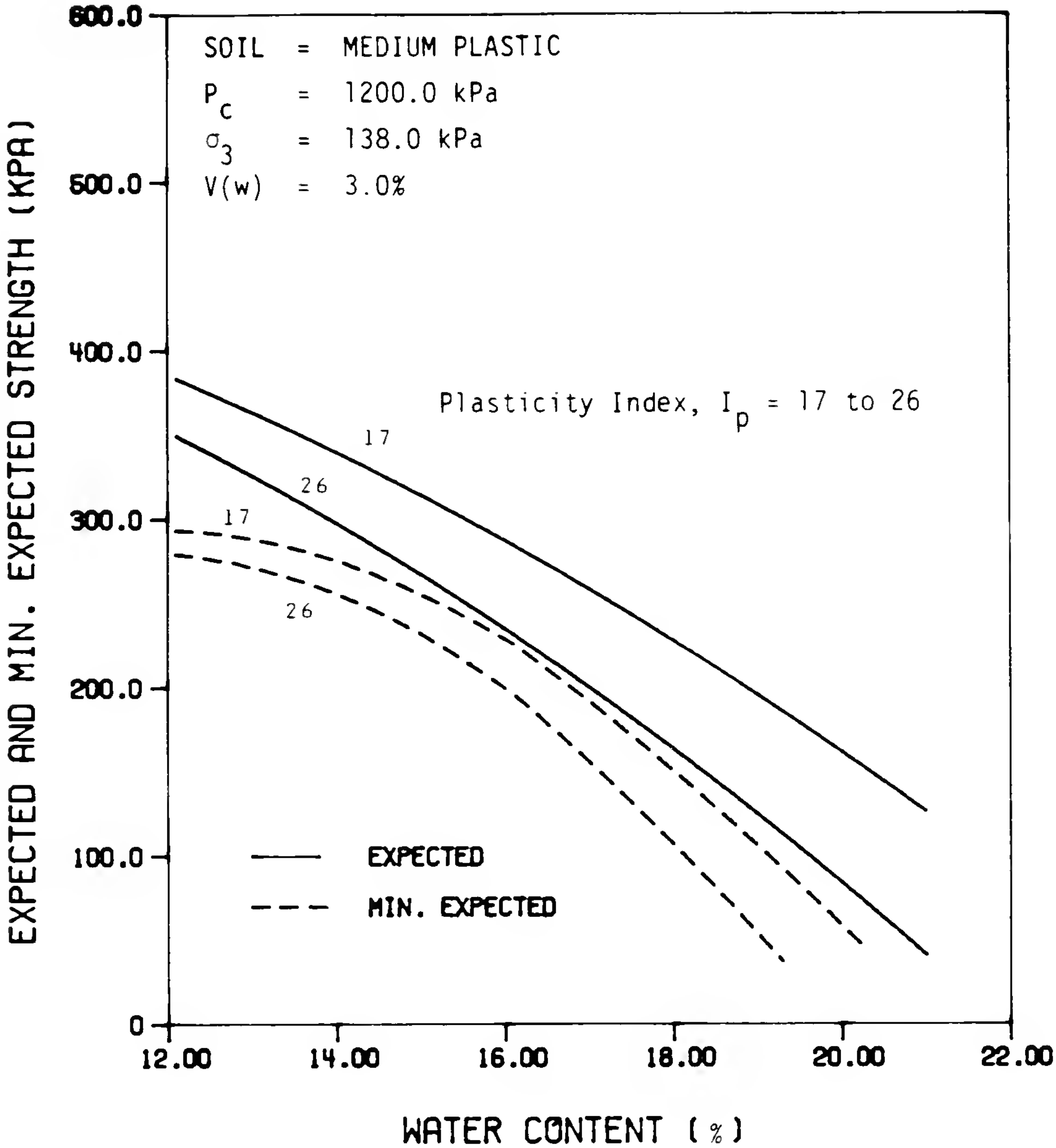

Figure 4.29 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

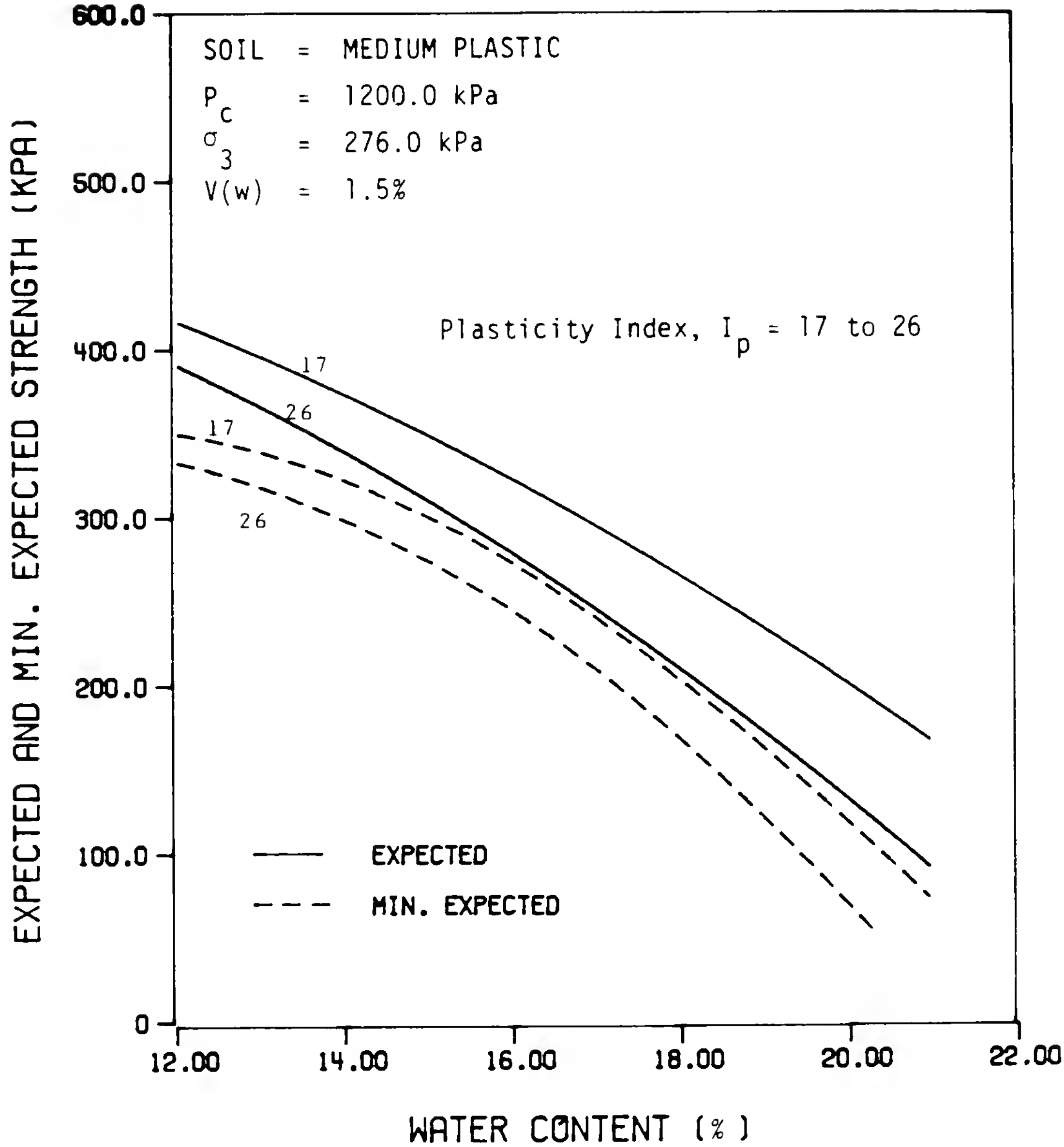

Figure 4.30 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

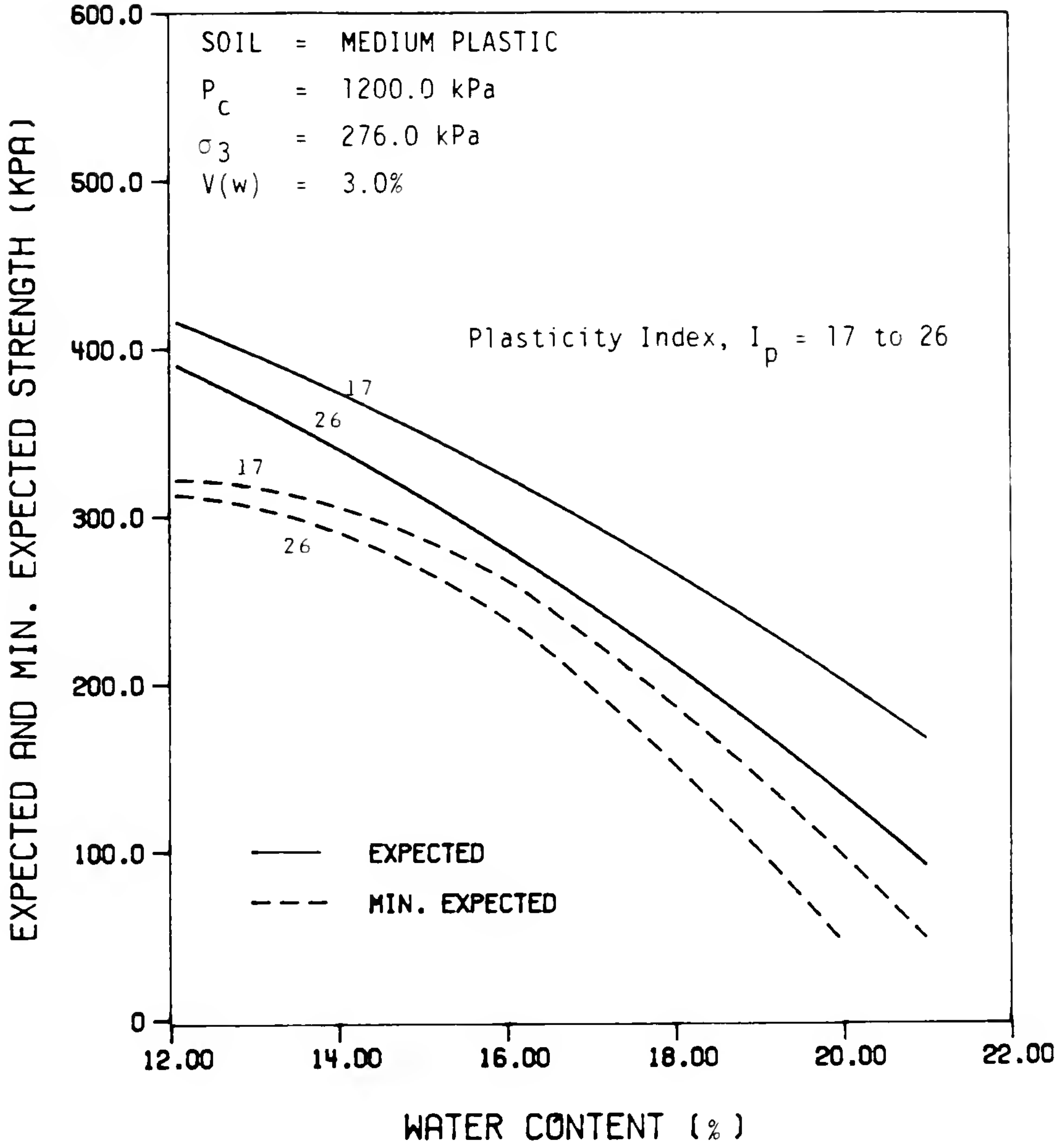

Figure 4.31 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

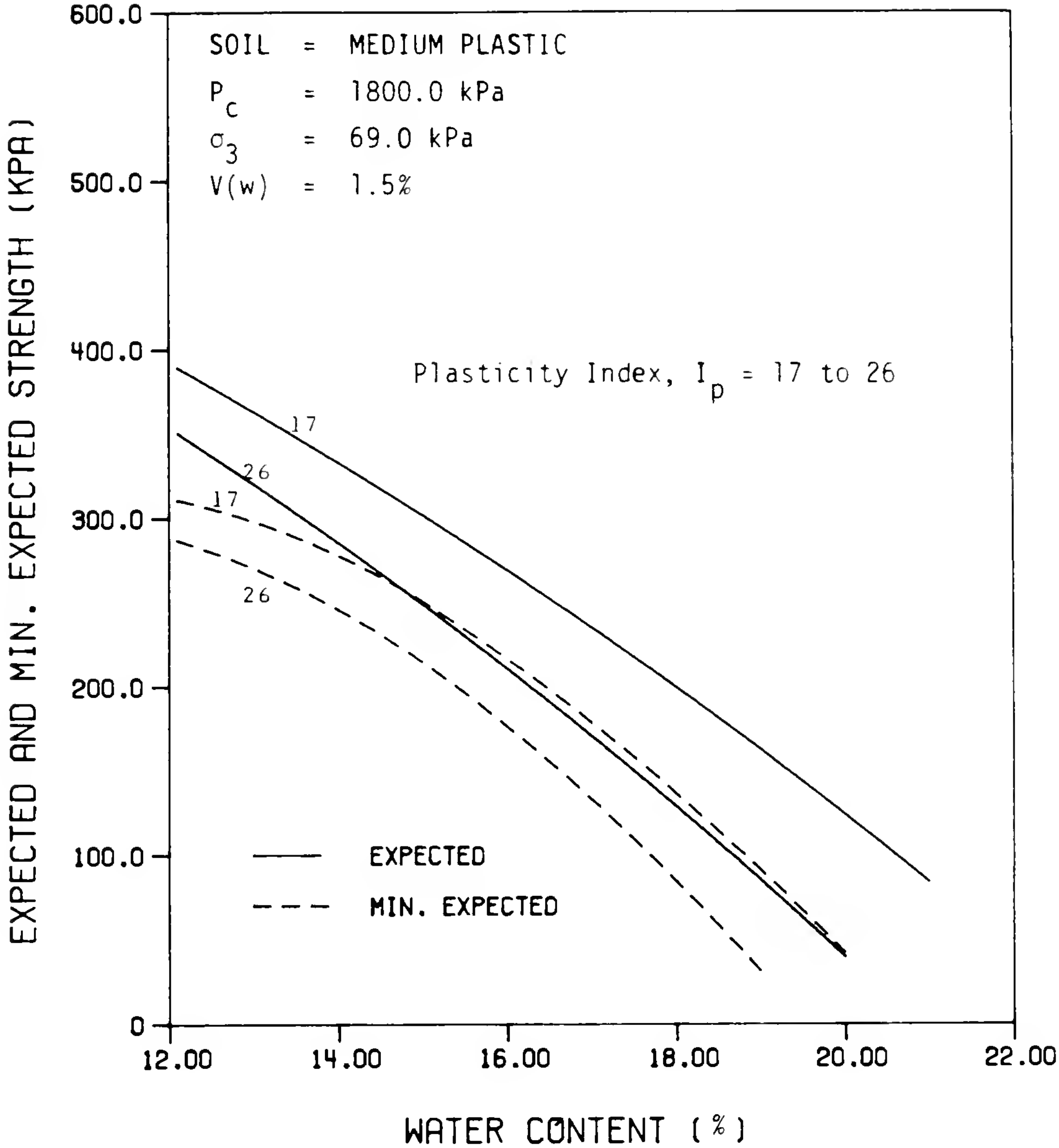

Figure 4.32 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

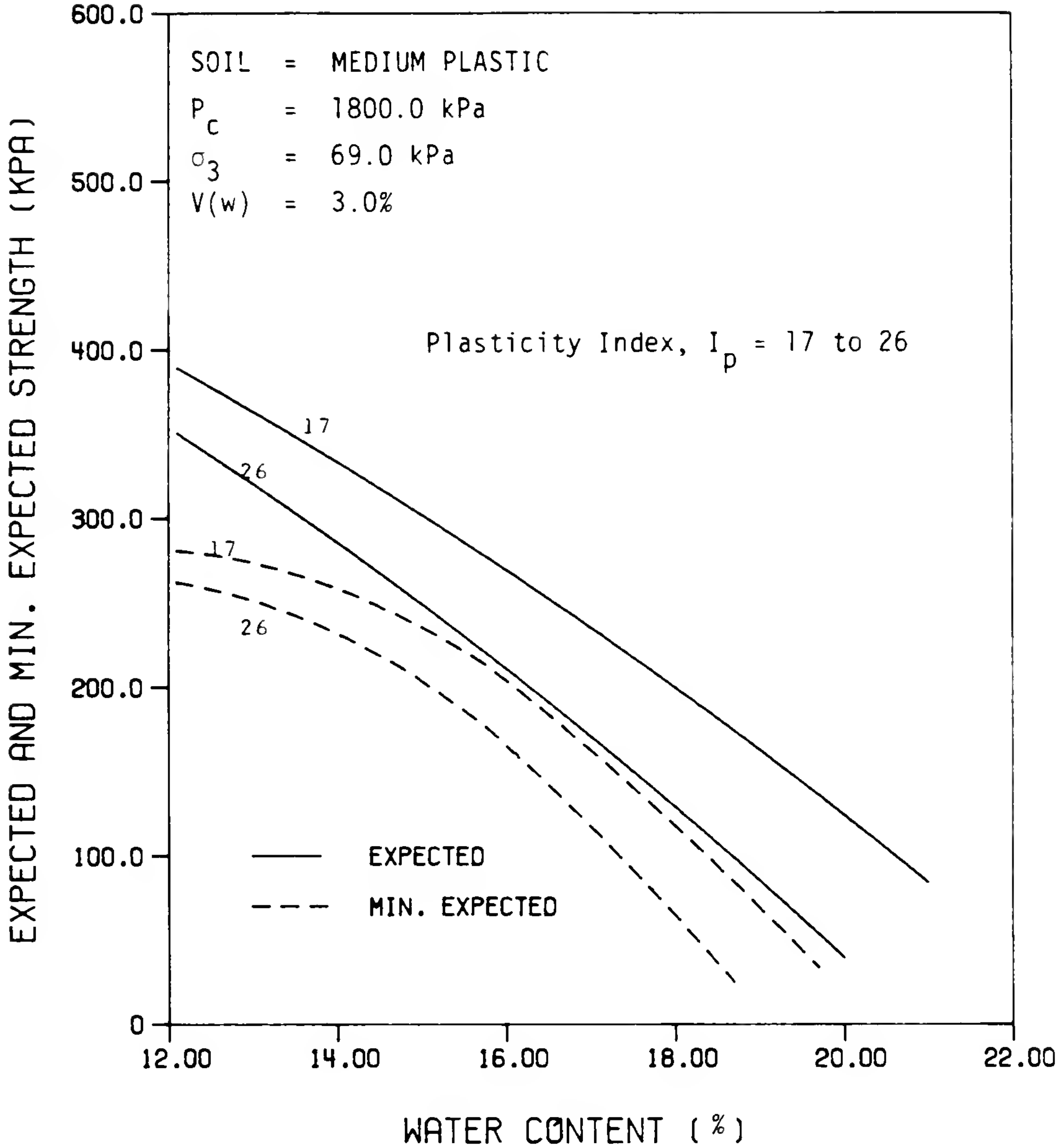

Figure 4.33 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

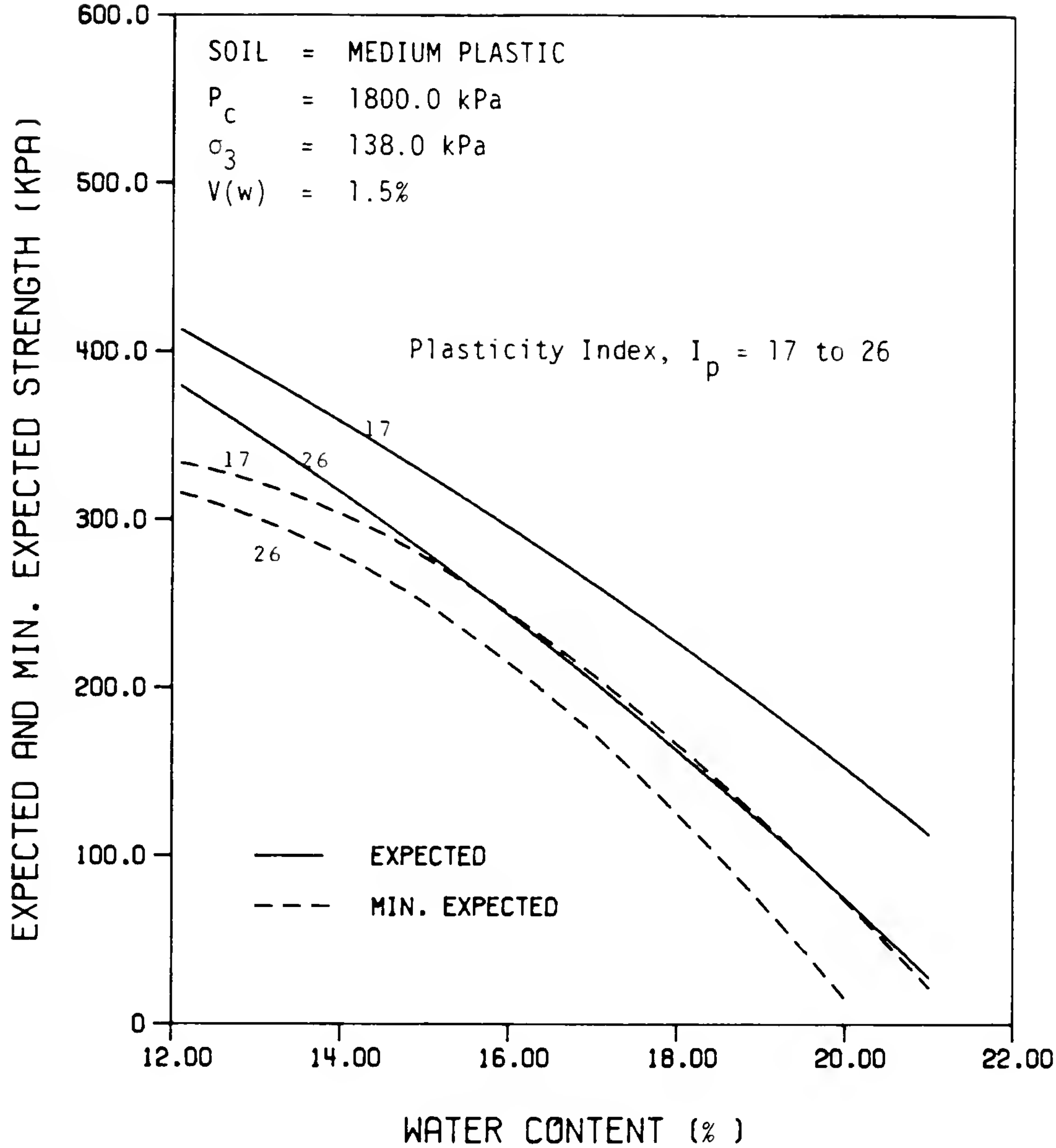

Figure 4.34 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

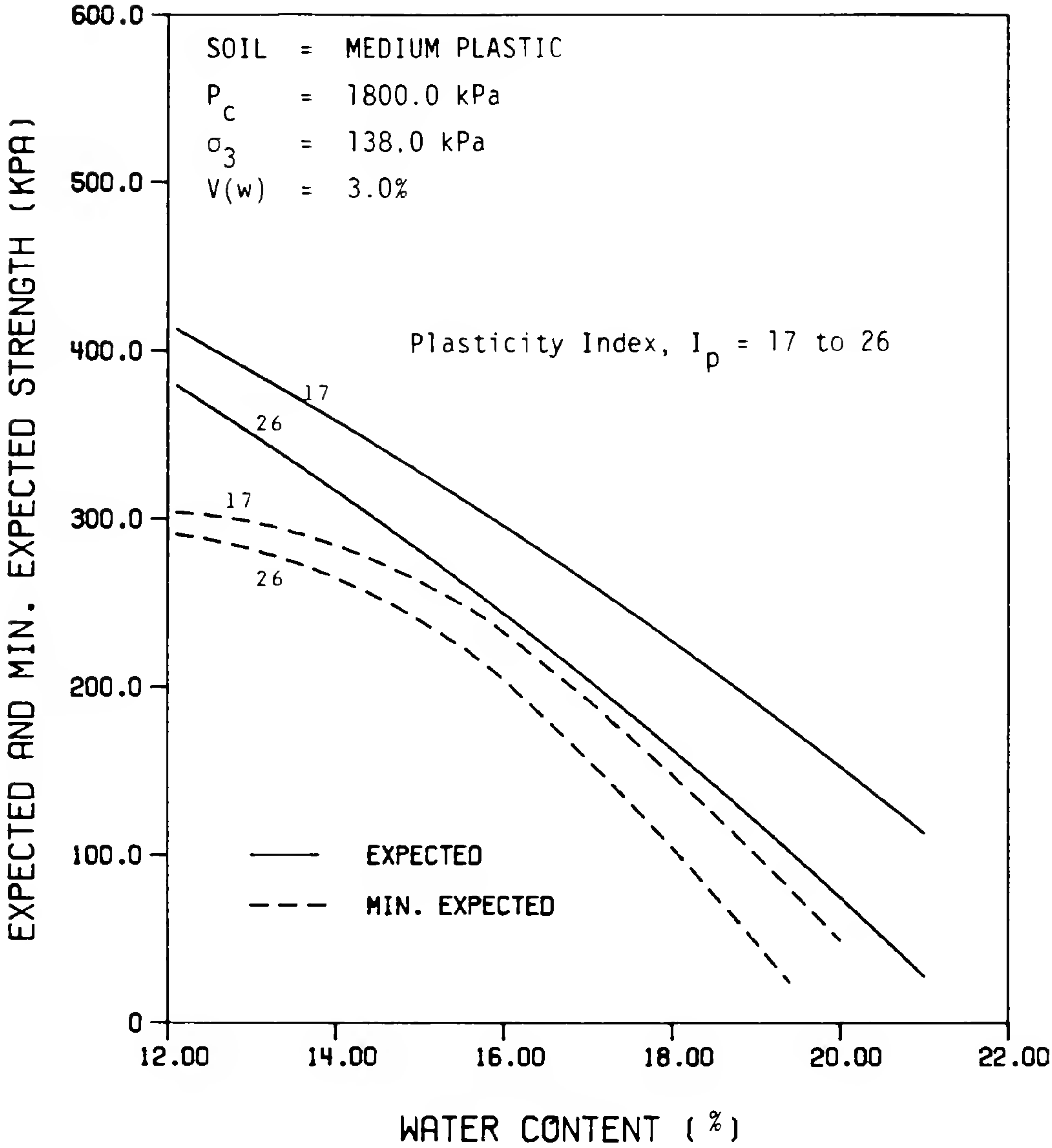

Figure 4.35 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

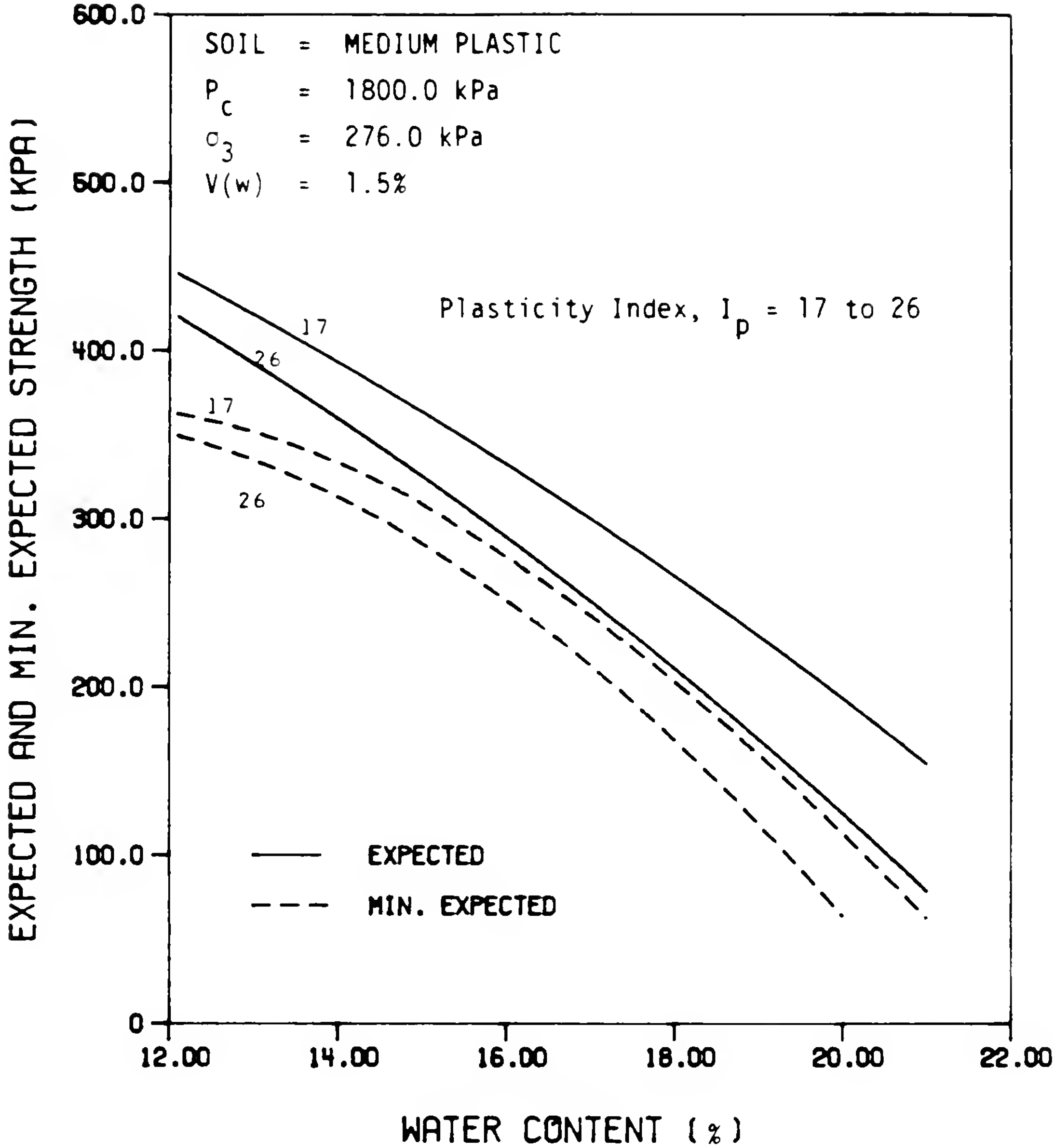

Figure 4.36 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

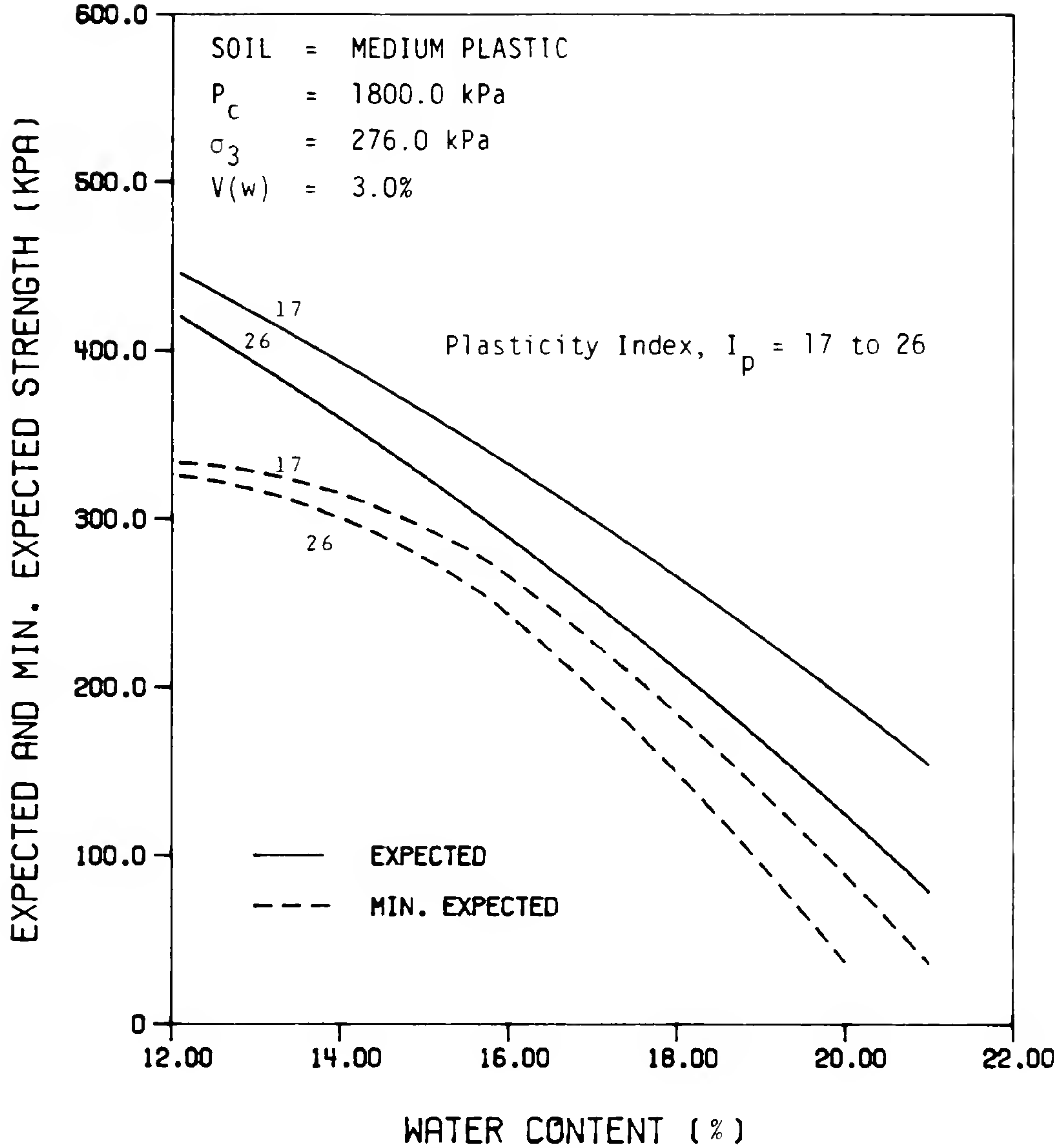

Figure 4.37 Design Chart for Field Confined Undrained Strength $\left(\frac{\sigma_1-\sigma_3}{2}\right)_f$

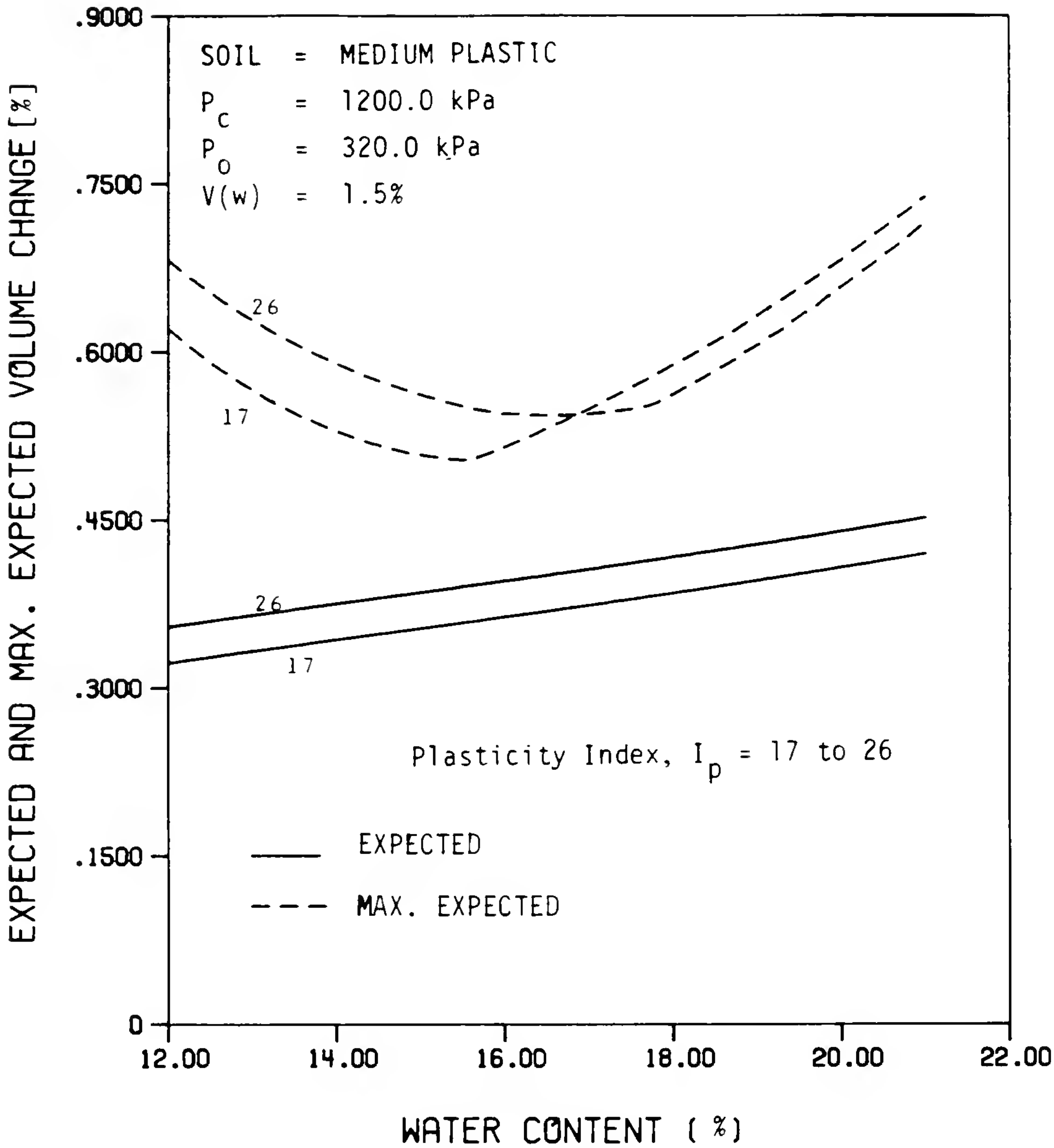

Figure 4.38 Design Chart for Field 1-D Volume Change for Soaking

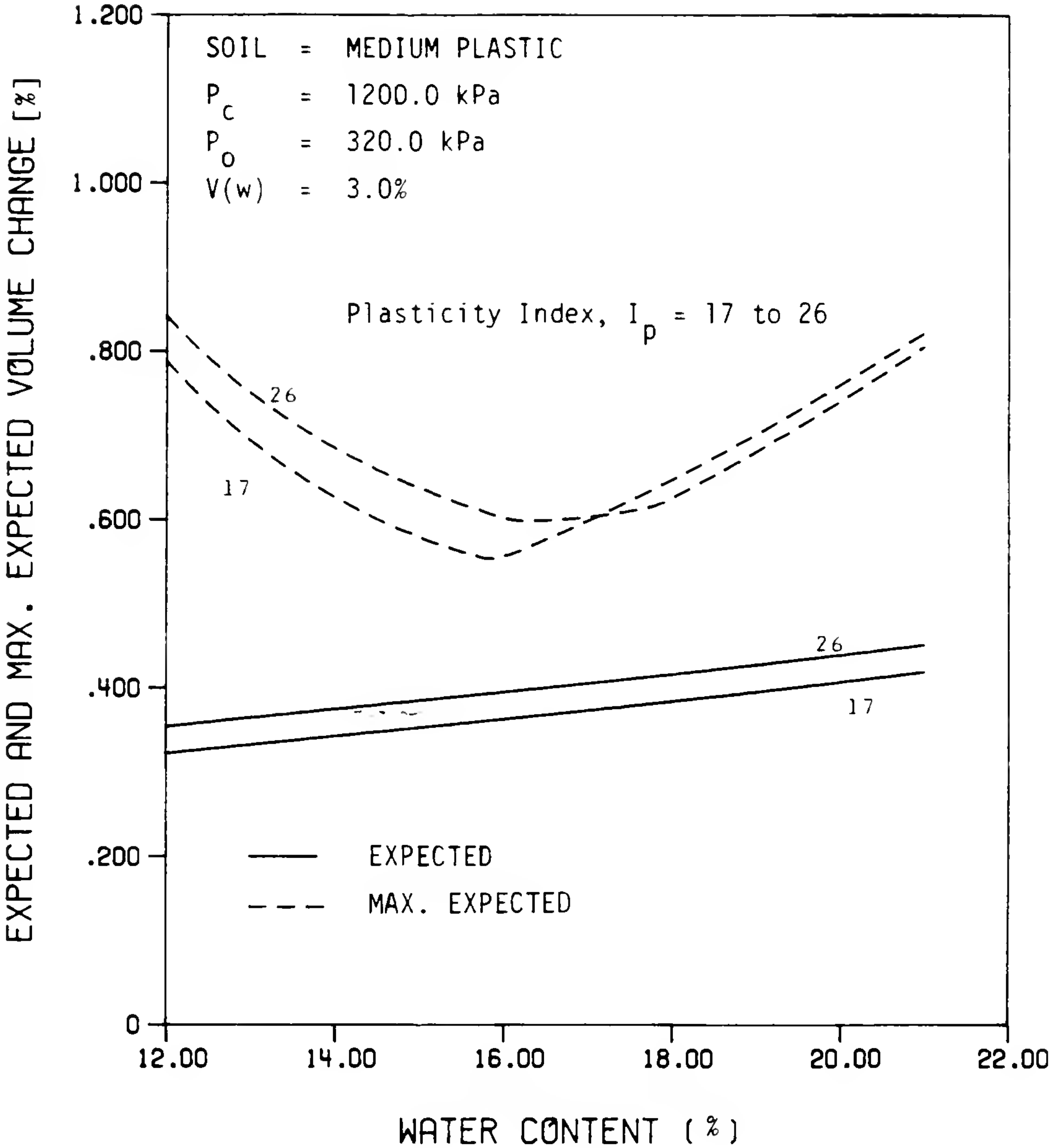

Figure 4.39 Design Chart for Field 1-D Volume Change on Soaking

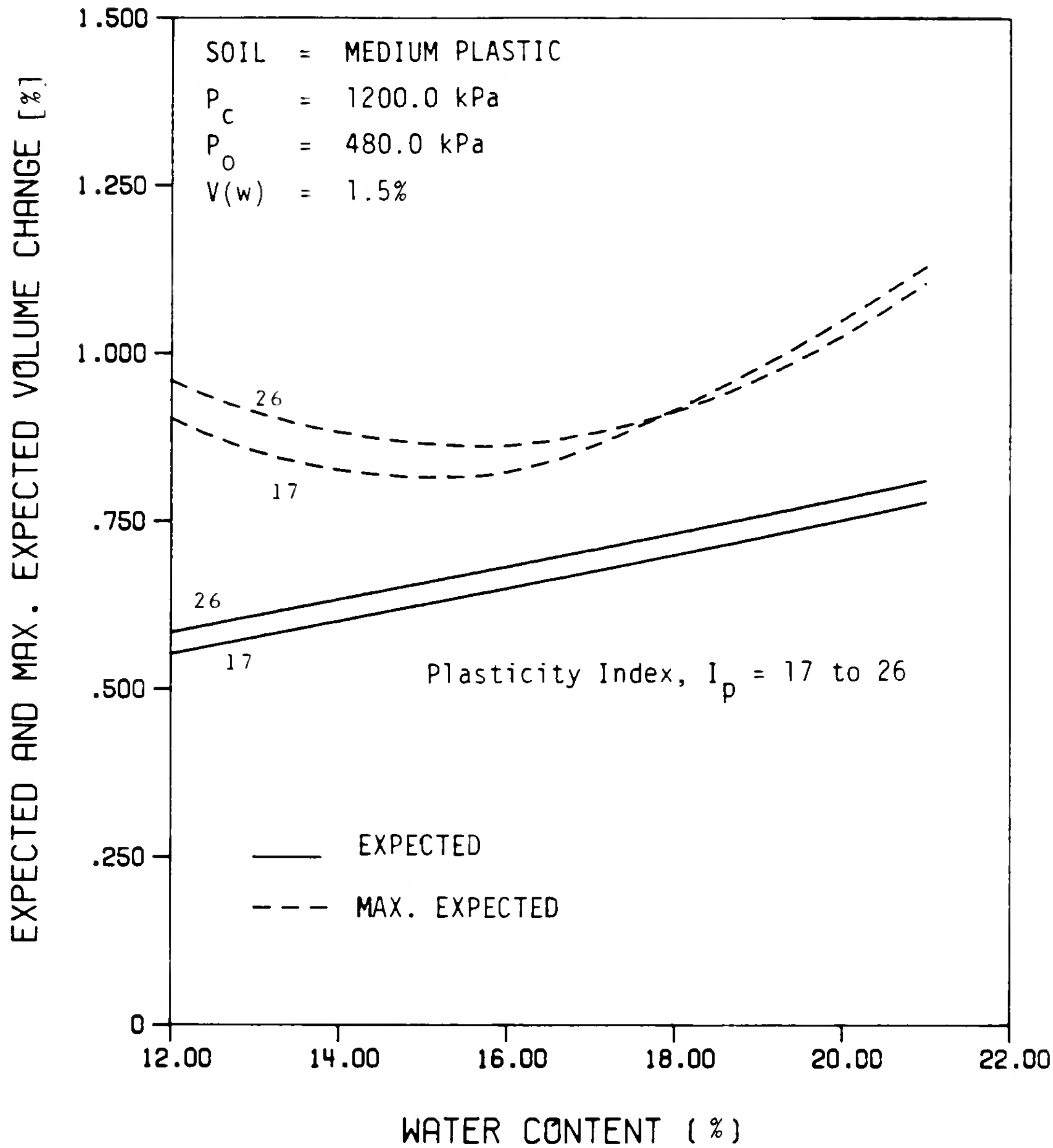

Figure 4.40 Design Chart for Field 1-D Volume Change on Soaking

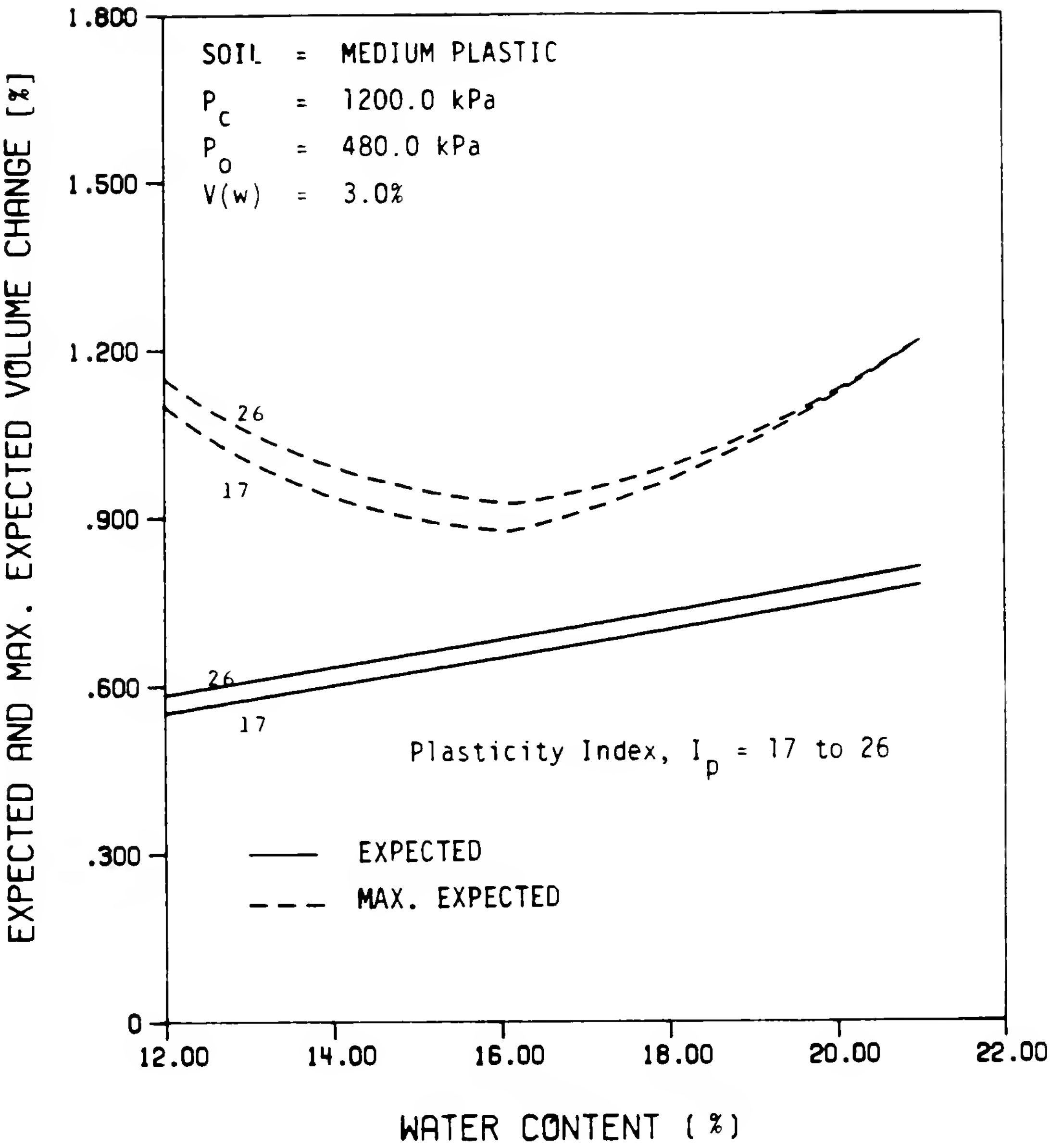

Figure 4.41 Design Chart for Field 1-D Volume Change on Soaking

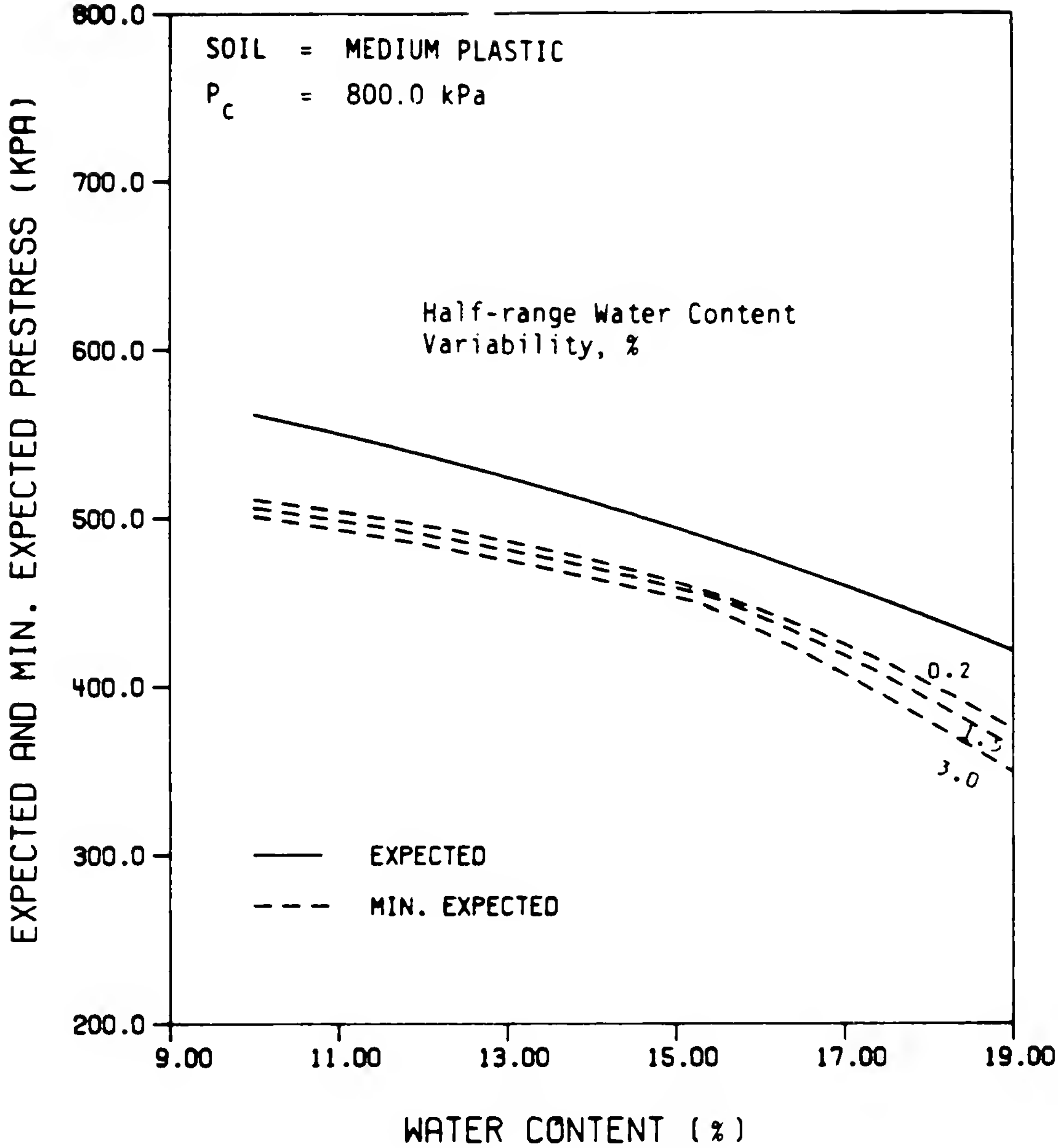

Figure 4.42 Design Chart for Field Prestress

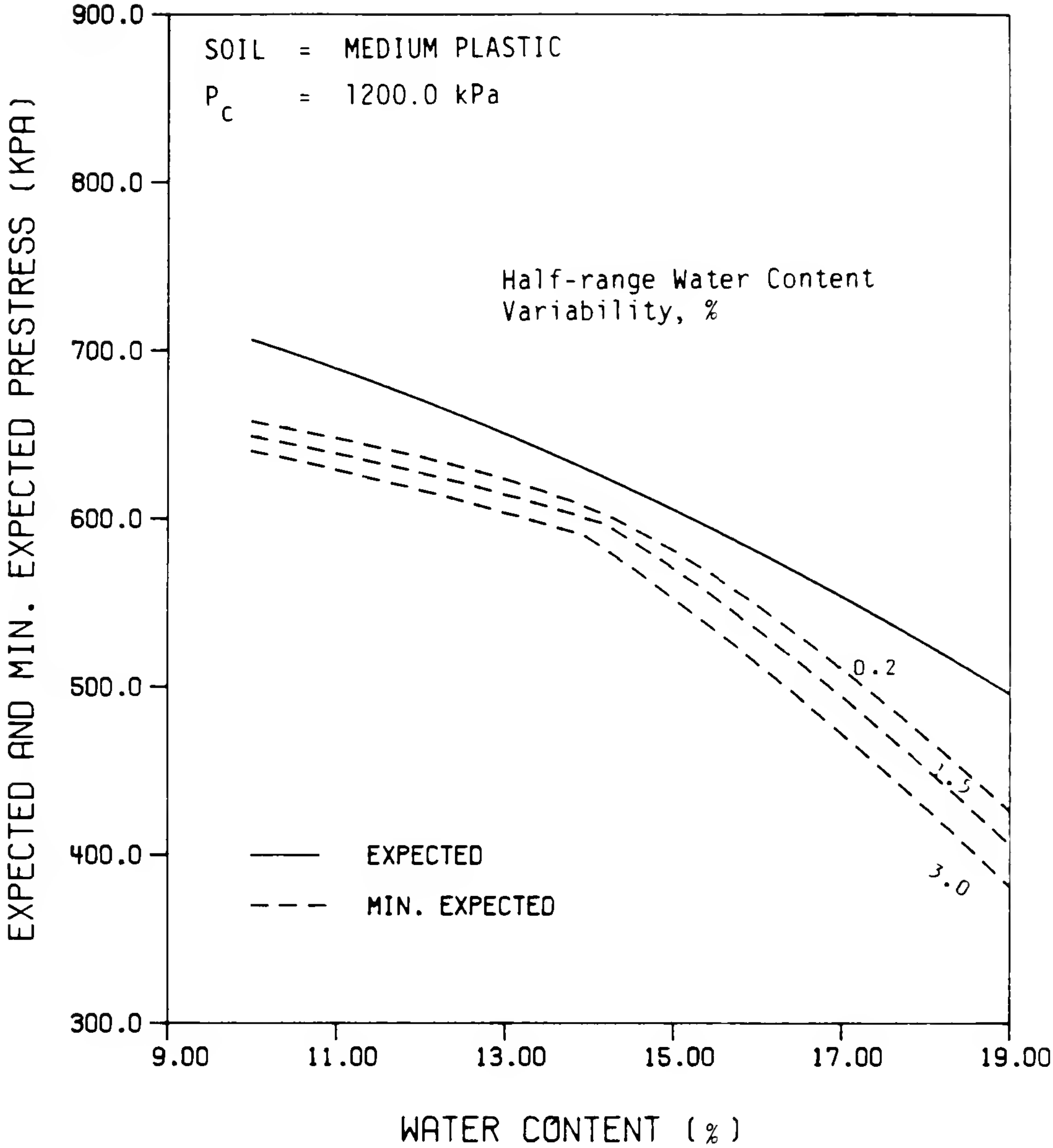

Figure 4.43 Design Chart for Field Prestress

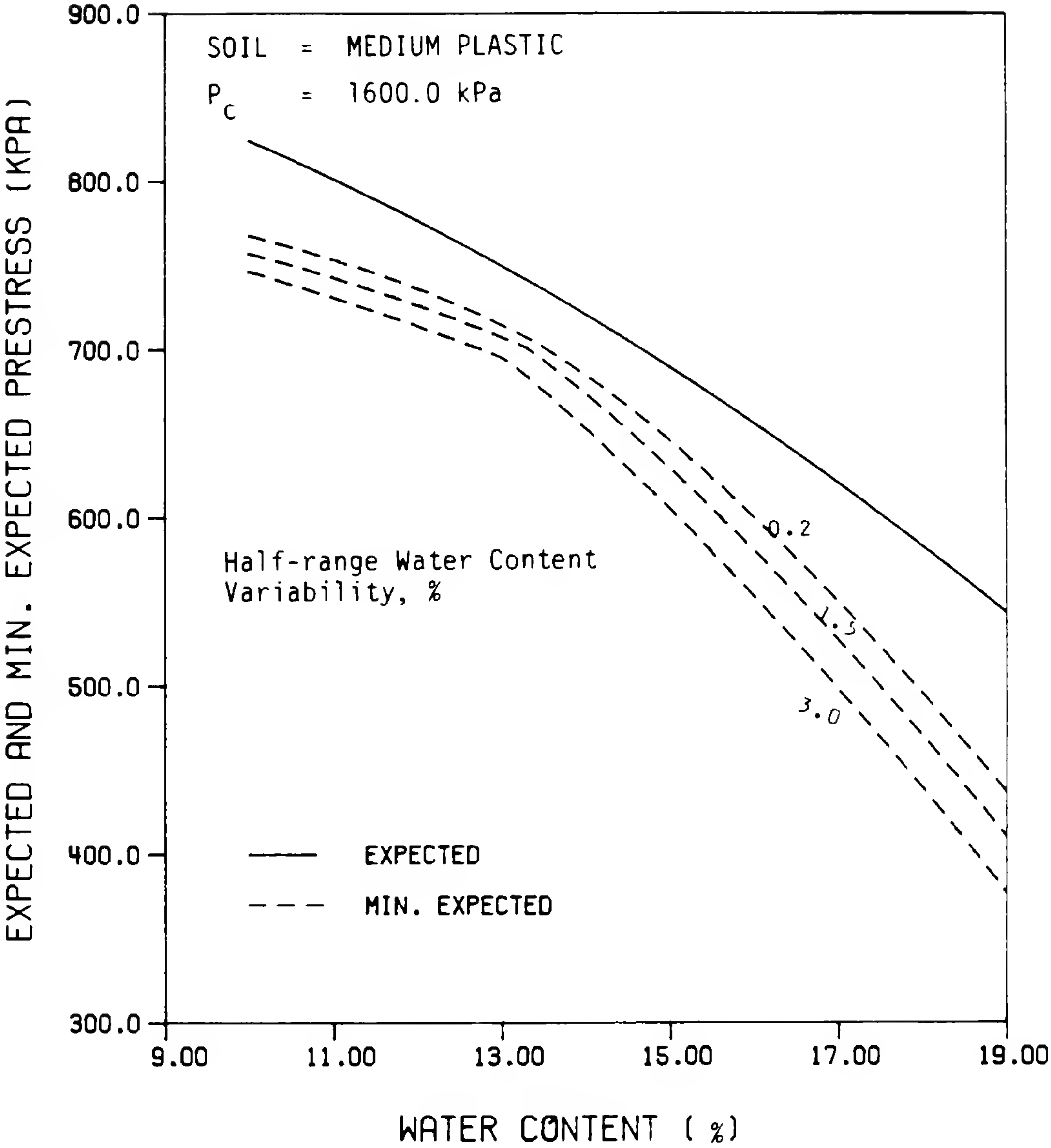

Figure 4.44 Design Chart for Field Prestress

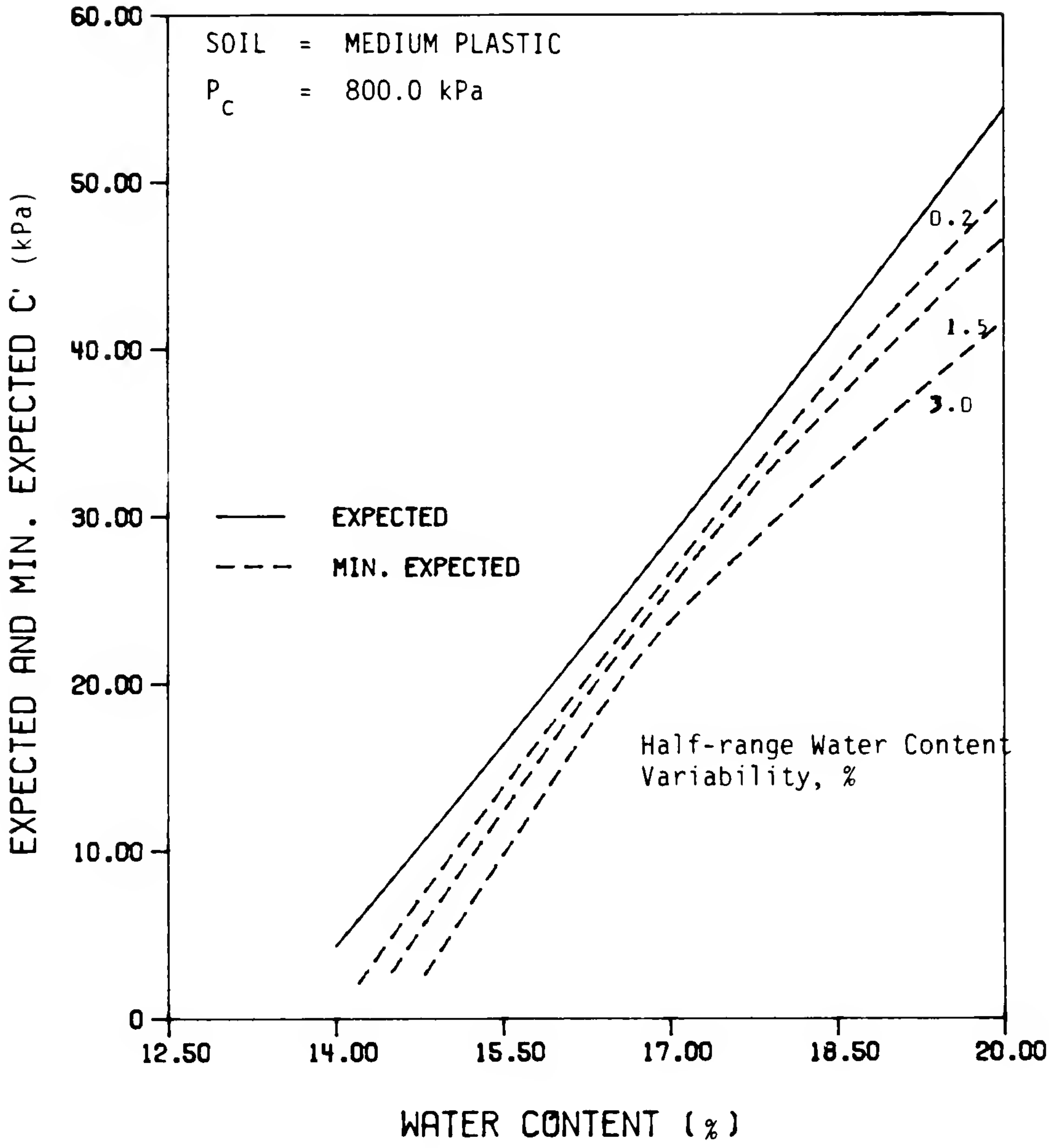

Figure 4.45 Design Chart for Effective Stress Strength Intercept

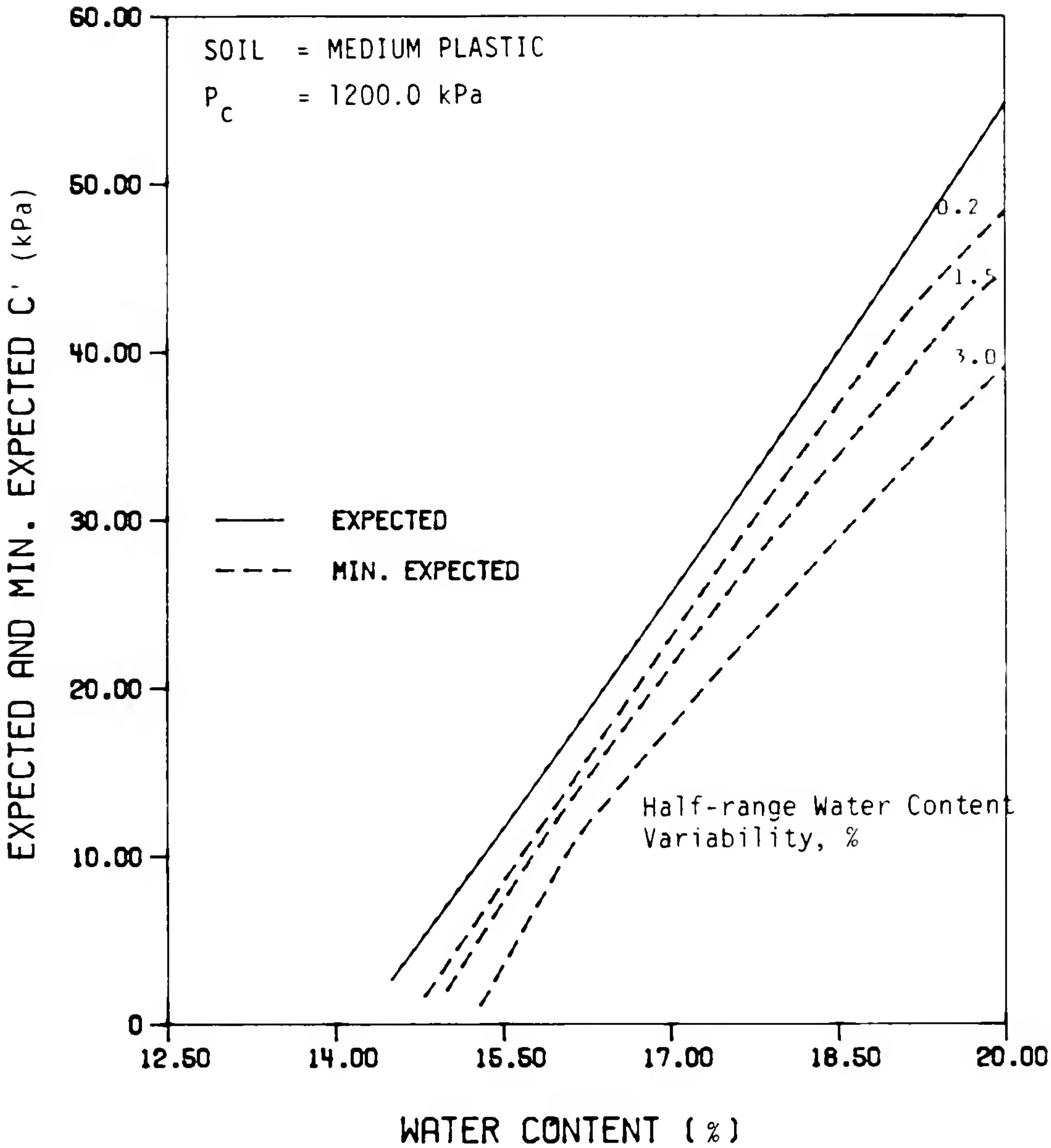

Figure 4.46 Design Chart for Effective Stress Strength Intercept

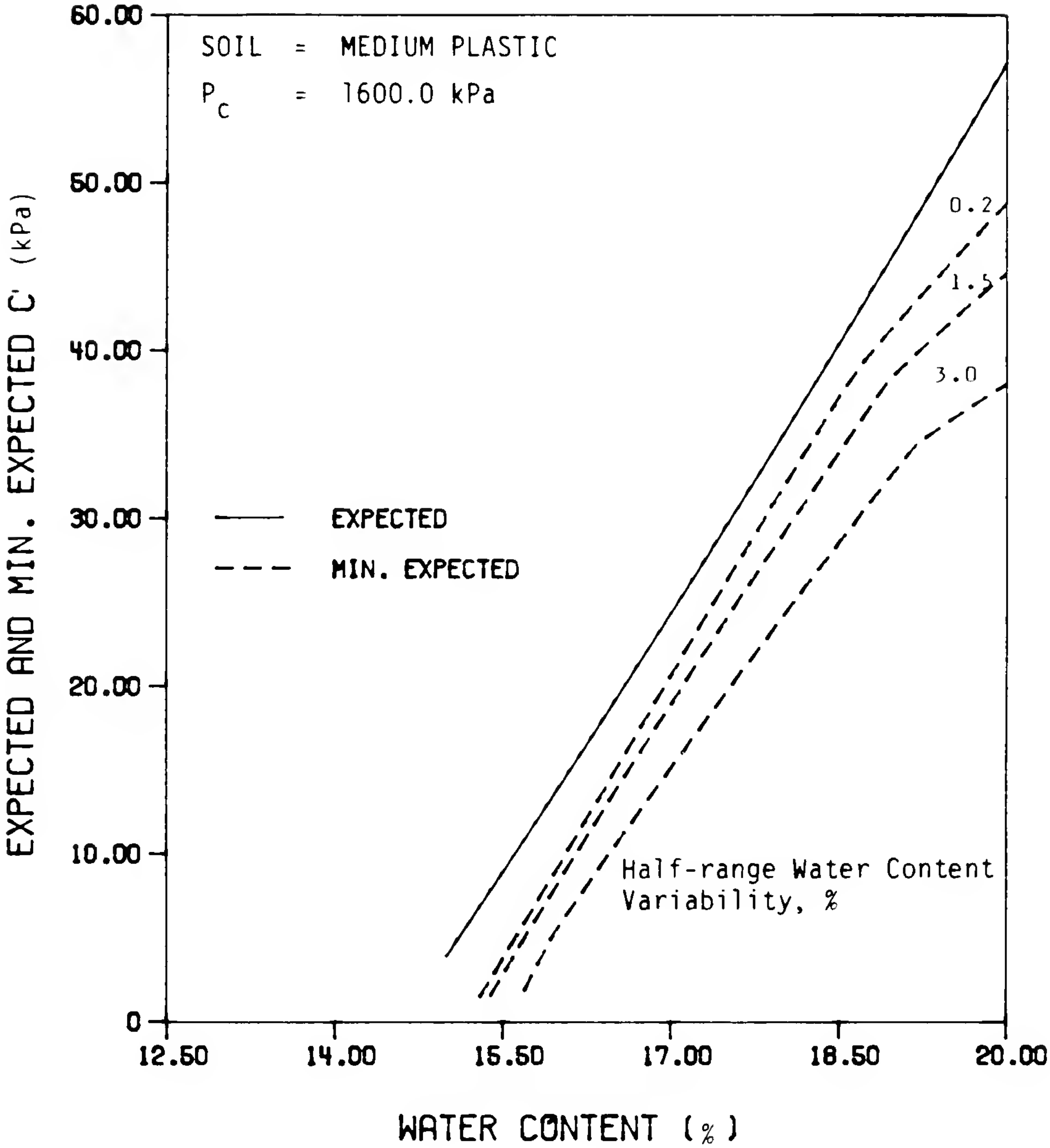

Figure 4.47 Design Chart for Effectiveness Stress Strength Intercept

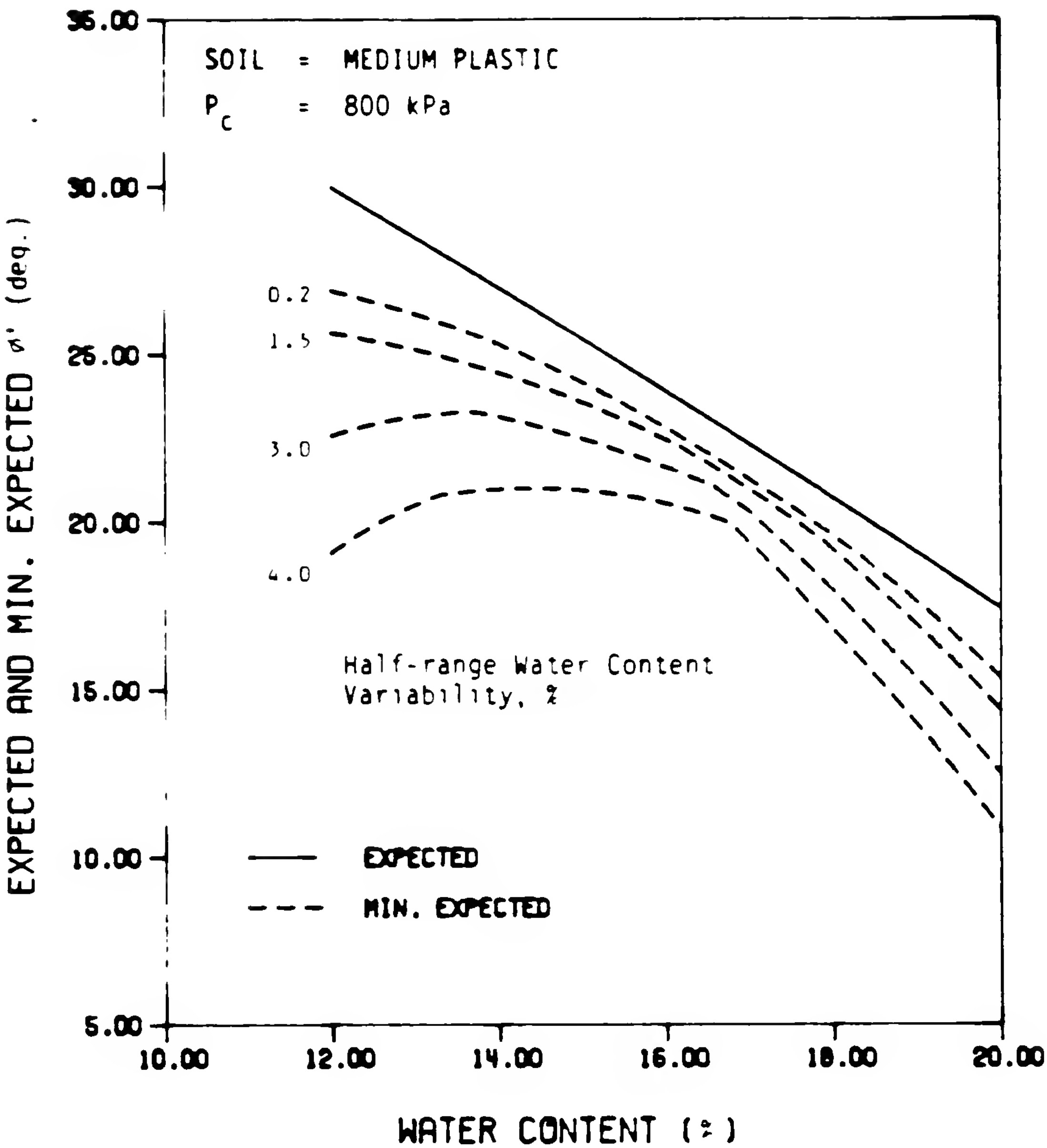

Figure 4.48 Design Chart for Effective Stress Strength Angle

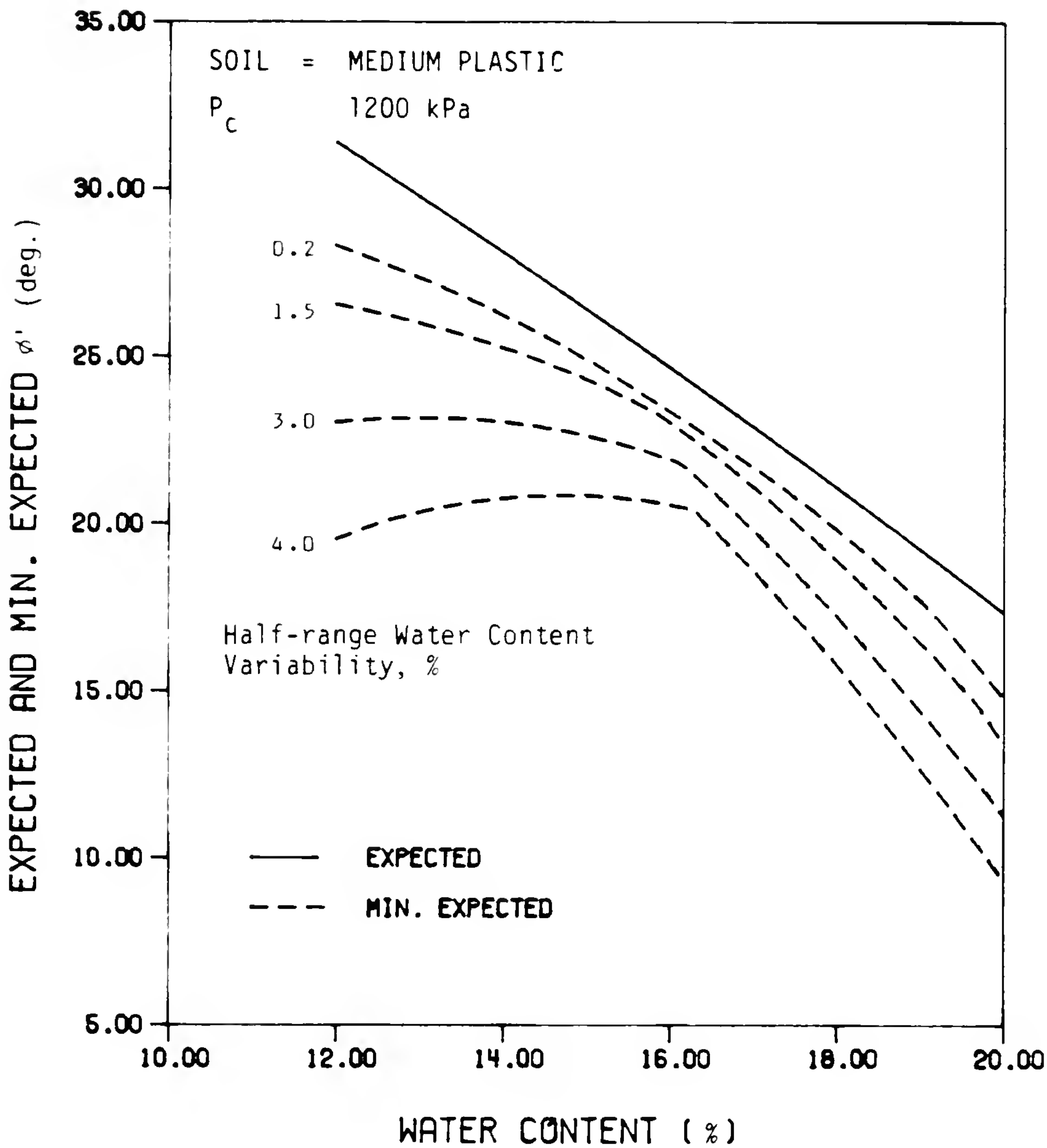

Figure 4.49 Design Chart for Effective Stress Strength Angle

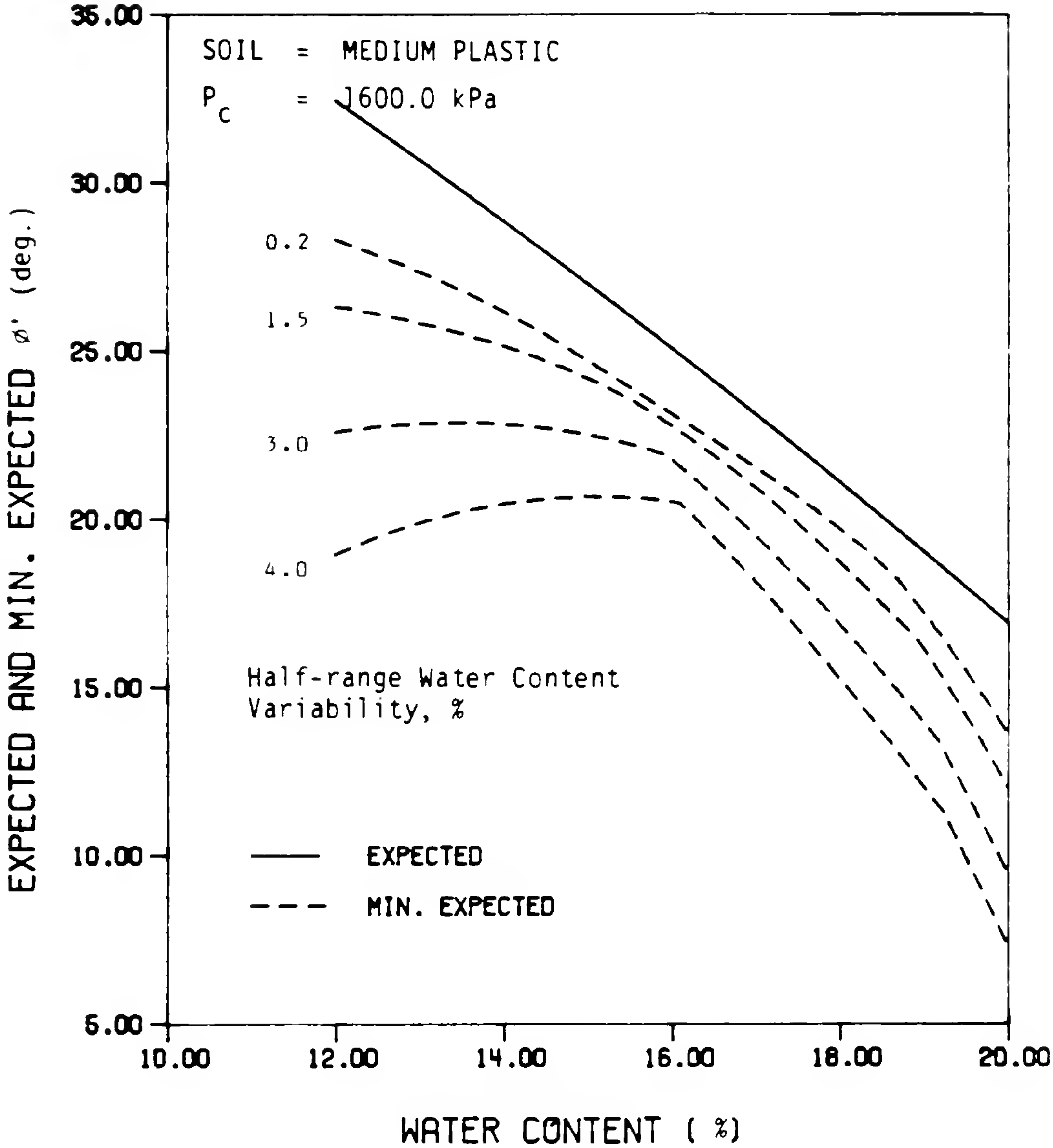

Figure 4.50 Design Chart for Effective Stress Strength Angle

Section 5

QUALITY ASSURANCE

This option is associated with the case where borrow is not known in advance of construction. Its purpose is to provide a means for predicting what will be the behaviour parameters that will be exhibited by the finished product. Figure 5.1 is the flow chart to guide one through the procedure.

The inspection test results from the lift being considered, as well as soil identification characteristics, must be obtained. The soil identification tests are to yield the Plasticity Index of the soil being used.

For inspection testing to be useful in this procedure, at least 7 measurements of dry density and water content must be made on the lift. The selection of test location should be based upon randomness, i.e., one can hypothetically grid the lift and use a table of random numbers to select the grid locations to be tested. Other similar procedures can be satisfactory, but inspectors should not bias the procedure by only searching for soft spots or other such aberrations on the lift. The tests should reflect the statistical variations that have been created. The number of roller passes must also have been counted for the locations selected.

Assuming that 8-inch loose lifts were being used and that the roller is one of the two rollers of this study, Table 3.1 is used to convert the number of passes to compaction energy. One then searches the quality assurance tables for that one which fits the Plasticity Index and compaction energy data for the lift in question.

The dry density table is first examined, and it yields the expected mean value and expected minimum value for the mean water content and the half-range in water content found in the lift. Interpolation can be used if lift values of water content data do not appear in the table (alternatively the program of Appendix D can be used to generate new tables). The tabular values and field lift values of dry density are compared, as a check. If field values do not agree with the tabular minimums, then any subsequent extractions from relations of this study might also be questionable. Thus the comparison is a check that the study relations are viable for the project.

Assuming the check comparison for dry density was favorable, behaviour parameters may now be predicted. The tabular value corresponding to the water content and compaction energy data will be the minimum assured magnitude of such parameters as strength and prestress or maximum assured magnitude for volume change due to soaking.

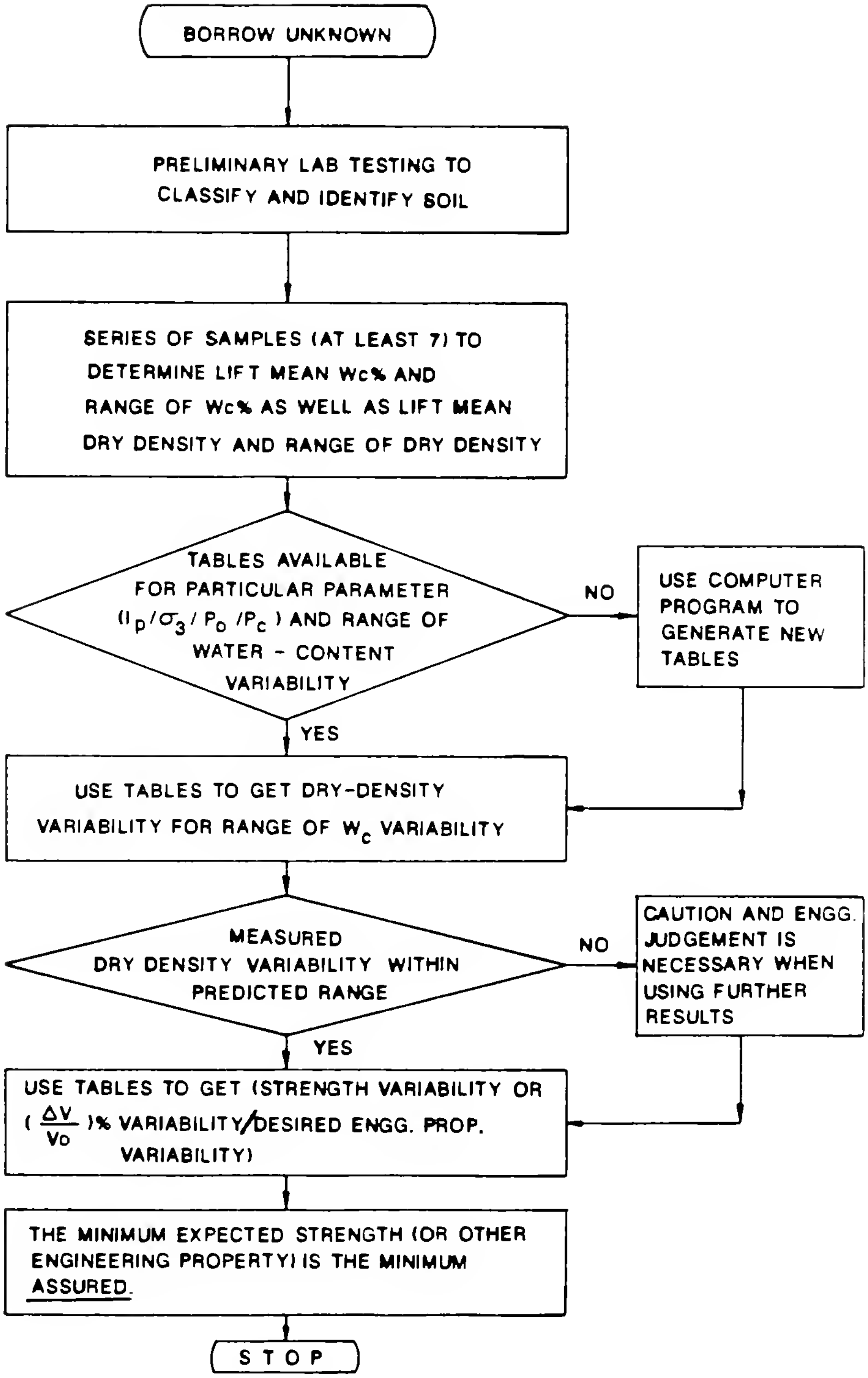

Figure 5.1 Flow Chart for Quality Assurance Option

It is certainly within bounds of the relations of this study to suggest that if the magnitudes predicted for the lift are not suitable, then construction changes can be suggested. Thos is done by them invoking the ideas of the DESIGN ENGINEERING option to create the compaction specification for subsequent lifts to create parameters that are more suitable. Obviously, to accomplish this procedure requires close involvement by the engineer in the construction operation.

5.2 A Quality Assurance Example

Let us assume the soil being compacted exhibits a Plasticity Index (I_p) of 12.0 and that compaction is being performed with 8-inch loose lifts by a Caterpillar 825 compactor. Futher, let us assume inspection testing yielded:

lift mean water content ($\overline{W}_c$) = 15 %

lift range of water content = 14 % to 17 %
which translates to a half-range
water content variability ($V_{(w)}$) = 1.5 %

lift mean dry density ($\overline{\gamma}_d$) = 1769.5 Kg/m^3 (110.23 pcf)

lift range of dry density = 1750 to 1790 Kg/m^3
(109 to 111.5 pcf)

Tables are available for low plastic soil for I_p = 12.0 for compaction energy levels from 600 to 1200 kPa (87 psi to 174 psi). Table 5.1 yields the following :

expected mean dry density ($\overline{\gamma}_d$) = 1776.1 Kg/m^3 (110.64 pcf)

expected minm dry density (γ_d) = 1745.6 Kg/m^3 (108.75 pcf)

Comparison with lift values indicates the relations of this study appear viable in this case and one may proceed.

Let us assume we are interested in that part of the embankment where confining stress will be 138 kPa (20 psi). Strength prediction tables are available for this case using Table 5.6 with (I_p = 12.0, $V_{(w)}$ = 1.5 %, σ_3 = 138 kPa, and, P_c = 600 - 1000 kPa) we get:

expected mean strength ($\bar{q}_c$) = 266.33 kPa (38.62 psi)

expected minm. strength = 152.15 kPa (22.07 psi)

This means that the engineer can expect a strength of 152 kPa with assurance for this lift.

In similar manner the magnitudes of the other parameters may also be predicted. If appropriate tables are not present in this report, then the computer program of Appendix D may be used to generate such tables.

Table 5.1

Dry Density - Low Plastic Soils

$V_{(w)}$=1.5%, I_p=12.0, Energy=600.0-1200.0kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)
10.00	1816.38	1723.60
10.25	1818.92	1732.87
10.50	1820.77	1740.90
10.75	1821.98	1747.78
11.00	1822.59	1753.60
11.25	1822.65	1758.44
11.50	1822.18	1762.37
11.75	1821.24	1765.45
12.00	1819.84	1767.76
12.25	1818.01	1769.33
12.50	1815.79	1770.22
12.75	1813.19	1770.47
13.00	1810.24	1770.12
13.25	1806.96	1769.19
13.50	1803.36	1767.74
13.75	1799.47	1765.76
14.00	1795.29	1763.30
14.25	1790.85	1760.37
14.50	1786.16	1756.99
14.75	1781.23	1751.86
15.00	1776.07	1745.60
15.25	1770.70	1739.01
15.50	1765.13	1732.13
15.75	1759.36	1724.95
16.00	1753.41	1717.51
16.25	1747.28	1709.82
16.50	1740.98	1701.89
16.75	1734.52	1693.73
17.00	1727.91	1685.36
17.25	1721.15	1676.79
17.50	1714.25	1668.02
17.75	1707.21	1659.07
18.00	1700.05	1649.94
18.25	1692.76	1640.64
18.50	1685.36	1631.18
18.75	1677.84	1621.57
19.00	1670.21	1611.81
19.25	1662.48	1601.91
19.50	1654.65	1591.87

Table 5.2

Strength - Low Plastic Soils

$V_{(w)}$=0.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress= 69 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1747.39	260.07	164.27
10.25	1818.92	1754.71	259.56	164.10
10.50	1820.77	1760.95	258.90	163.78
10.75	1821.98	1766.19	258.10	163.31
11.00	1822.59	1770.51	257.15	162.72
11.25	1822.65	1773.96	256.07	162.00
11.50	1822.18	1776.61	254.86	161.17
11.75	1821.24	1778.51	253.51	160.22
12.00	1819.84	1779.71	252.03	159.17
12.25	1818.01	1780.25	250.42	158.01
12.50	1815.79	1780.17	248.68	156.76
12.75	1813.19	1779.49	246.81	155.42
13.00	1810.24	1778.25	244.82	153.99
13.25	1806.96	1776.48	242.70	152.46
13.50	1803.36	1774.19	240.45	150.85
13.75	1799.47	1771.40	238.09	149.15
14.00	1795.29	1768.13	235.60	147.36
14.25	1790.85	1764.40	233.00	145.48
14.50	1786.16	1760.22	230.27	143.52
14.75	1781.23	1755.01	227.42	141.41
15.00	1776.07	1749.28	224.46	139.21
15.25	1770.70	1743.19	221.38	136.90
15.50	1765.13	1736.75	218.18	134.51
15.75	1759.36	1729.99	214.87	132.01
16.00	1753.41	1722.93	211.45	129.41
16.25	1747.28	1715.59	207.91	126.70
16.50	1740.98	1707.97	204.25	123.88
16.75	1734.52	1700.11	200.48	120.95
17.00	1727.91	1692.01	196.60	117.90
17.25	1721.15	1683.69	192.61	114.72
17.50	1714.25	1675.16	188.51	111.41
17.75	1707.21	1666.43	184.30	107.95
18.00	1700.05	1657.51	179.97	104.35
18.25	1692.76	1648.41	175.54	100.55
18.50	1685.36	1639.13	171.00	96.28
18.75	1677.84	1629.70	166.35	91.79
19.00	1670.21	1620.10	161.59	87.07
19.25	1662.48	1610.36	156.72	82.11
19.50	1654.65	1600.48	151.74	76.90

Table 5.3

Strength - Low Plastic Soils

$V_{(w)}$=1.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress= 69 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1723.60	260.07	162.32
10.25	1818.92	1732.87	259.56	162.28
10.50	1820.77	1740.90	258.90	162.07
10.75	1821.98	1747.78	258.10	161.69
11.00	1822.59	1753.60	257.15	161.16
11.25	1822.65	1758.44	256.07	160.49
11.50	1822.18	1762.37	254.86	159.69
11.75	1821.24	1765.45	253.51	158.76
12.00	1819.84	1767.76	252.03	157.71
12.25	1818.01	1769.33	250.42	156.55
12.50	1815.79	1770.22	248.68	155.28
12.75	1813.19	1770.47	246.81	153.91
13.00	1810.24	1770.12	244.82	152.44
13.25	1806.96	1769.19	242.70	150.89
13.50	1803.36	1767.74	240.45	149.24
13.75	1799.47	1765.76	238.09	147.50
14.00	1795.29	1763.30	235.60	145.68
14.25	1790.85	1760.37	233.00	143.77
14.50	1786.16	1756.99	230.27	141.78
14.75	1781.23	1751.86	227.42	139.62
15.00	1776.07	1745.60	224.46	137.32
15.25	1770.70	1739.01	221.38	134.93
15.50	1765.13	1732.13	218.18	132.46
15.75	1759.36	1724.95	214.87	129.89
16.00	1753.41	1717.51	211.45	127.24
16.25	1747.28	1709.82	207.91	124.49
16.50	1740.98	1701.89	204.25	121.66
16.75	1734.52	1693.73	200.48	118.72
17.00	1727.91	1685.36	196.60	115.69
17.25	1721.15	1676.79	192.61	112.56
17.50	1714.25	1668.02	188.51	109.31
17.75	1707.21	1659.07	184.30	105.95
18.00	1700.05	1649.94	179.97	102.48
18.25	1692.76	1640.64	175.54	98.36
18.50	1685.36	1631.18	171.00	93.62
18.75	1677.84	1621.57	166.35	88.64
19.00	1670.21	1611.81	161.59	83.40
19.25	1662.48	1601.91	156.72	77.90
19.50	1654.65	1591.87	151.74	72.12

Table 5.4

Strength - Low Plastic Soils

$V_{(w)}$=3.0 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress= 69 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1667.74	260.07	156.13
10.25	1818.92	1681.84	259.56	157.45
10.50	1820.77	1694.21	258.90	158.41
10.75	1821.98	1705.03	258.10	158.44
11.00	1822.59	1714.42	257.15	158.14
11.25	1822.65	1722.50	256.07	157.65
11.50	1822.18	1729.40	254.86	156.99
11.75	1821.24	1735.19	253.51	156.18
12.00	1819.84	1739.97	252.03	155.22
12.25	1818.01	1743.82	250.42	154.12
12.50	1815.79	1746.80	248.68	152.89
12.75	1813.19	1748.98	246.81	151.53
13.00	1810.24	1750.42	244.82	150.06
13.25	1806.96	1751.17	242.70	148.48
13.50	1803.36	1751.28	240.45	146.79
13.75	1799.47	1750.78	238.09	145.01
14.00	1795.29	1749.72	235.60	143.13
14.25	1790.85	1748.13	233.00	141.16
14.50	1786.16	1746.03	230.27	139.10
14.75	1781.23	1743.47	227.42	136.96
15.00	1776.07	1736.99	224.46	134.55
15.25	1770.70	1729.92	221.38	132.03
15.50	1765.13	1722.59	218.18	129.43
15.75	1759.36	1715.00	214.87	126.73
16.00	1753.41	1707.18	211.45	123.96
16.25	1747.28	1699.13	207.91	121.10
16.50	1740.98	1690.87	204.25	118.16
16.75	1734.52	1682.40	200.48	115.14
17.00	1727.91	1673.73	196.60	112.04
17.25	1721.15	1664.88	192.61	108.85
17.50	1714.25	1655.84	188.51	105.57
17.75	1707.21	1646.64	184.30	101.96
18.00	1700.05	1637.27	179.97	96.94
18.25	1692.76	1627.75	175.54	91.65
18.50	1685.36	1618.07	171.00	86.09
18.75	1677.84	1608.25	166.35	80.26
19.00	1670.21	1598.28	161.59	74.15
19.25	1662.48	1588.19	156.72	67.75
19.50	1654.65	1577.96	151.74	61.06

Table 5.5

Strength - Low Plastic Soils

$V_{(w)}$=0.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress=138 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1747.39	284.53	192.02
10.25	1818.92	1754.71	285.10	191.59
10.50	1820.77	1760.95	285.49	190.95
10.75	1821.98	1766.19	285.72	190.12
11.00	1822.59	1770.51	285.78	189.13
11.25	1822.65	1773.96	285.69	187.97
11.50	1822.18	1776.61	285.43	186.68
11.75	1821.24	1778.51	285.01	185.26
12.00	1819.84	1779.71	284.45	183.71
12.25	1818.01	1780.25	283.73	182.06
12.50	1815.79	1780.17	282.86	180.30
12.75	1813.19	1779.49	281.84	178.44
13.00	1810.24	1778.25	280.68	176.48
13.25	1806.96	1776.48	279.37	174.44
13.50	1803.36	1774.19	277.92	172.30
13.75	1799.47	1771.40	276.34	170.08
14.00	1795.29	1768.13	274.61	167.77
14.25	1790.85	1764.40	272.74	165.37
14.50	1786.16	1760.22	270.74	162.89
14.75	1781.23	1755.01	268.60	160.23
15.00	1776.07	1749.28	266.33	157.46
15.25	1770.70	1743.19	263.93	154.60
15.50	1765.13	1736.75	261.40	151.66
15.75	1759.36	1729.99	258.73	148.63
16.00	1753.41	1722.93	255.94	145.52
16.25	1747.28	1715.59	253.01	142.32
16.50	1740.98	1707.97	249.96	139.03
16.75	1734.52	1700.11	246.79	135.65
17.00	1727.91	1692.01	243.48	132.18
17.25	1721.15	1683.69	240.05	128.62
17.50	1714.25	1675.16	236.50	124.97
17.75	1707.21	1666.43	232.82	121.21
18.00	1700.05	1657.51	229.02	117.35
18.25	1692.76	1648.41	225.10	113.38
18.50	1685.36	1639.13	221.06	109.31
18.75	1677.84	1629.70	216.89	105.11
19.00	1670.21	1620.10	212.61	100.80
19.25	1662.48	1610.36	208.20	96.36
19.50	1654.65	1600.48	203.67	91.79

Table 5.6

Strength - Low Plastic Soils

$V_{(w)}$=1.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress=138 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1723.60	284.53	184.38
10.25	1818.92	1732.87	285.10	183.83
10.50	1820.77	1740.90	285.49	183.12
10.75	1821.98	1747.78	285.72	182.28
11.00	1822.59	1753.60	285.78	181.31
11.25	1822.65	1758.44	285.69	180.22
11.50	1822.18	1762.37	285.43	179.02
11.75	1821.24	1765.45	285.01	177.71
12.00	1819.84	1767.76	284.45	176.30
12.25	1818.01	1769.33	283.73	174.80
12.50	1815.79	1770.22	282.86	173.21
12.75	1813.19	1770.47	281.84	171.53
13.00	1810.24	1770.12	280.68	169.77
13.25	1806.96	1769.19	279.37	167.92
13.50	1803.36	1767.74	277.92	166.00
13.75	1799.47	1765.76	276.34	163.99
14.00	1795.29	1763.30	274.61	161.90
14.25	1790.85	1760.37	272.74	159.73
14.50	1786.16	1756.99	270.74	157.47
14.75	1781.23	1751.86	268.60	154.92
15.00	1776.07	1745.60	266.33	152.15
15.25	1770.70	1739.01	263.93	149.29
15.50	1765.13	1732.13	261.40	146.35
15.75	1759.36	1724.95	258.73	143.32
16.00	1753.41	1717.51	255.94	140.21
16.25	1747.28	1709.82	253.01	137.00
16.50	1740.98	1701.89	249.96	133.70
16.75	1734.52	1693.73	246.79	130.30
17.00	1727.91	1685.36	243.48	126.81
17.25	1721.15	1676.79	240.05	123.21
17.50	1714.25	1668.02	236.50	119.51
17.75	1707.21	1659.07	232.82	115.70
18.00	1700.05	1649.94	229.02	111.77
18.25	1692.76	1640.64	225.10	107.73
18.50	1685.36	1631.18	221.06	103.56
18.75	1677.84	1621.57	216.89	99.26
19.00	1670.21	1611.81	212.61	94.82
19.25	1662.48	1601.91	208.20	90.24
19.50	1654.65	1591.87	203.67	85.52

Table 5.7

Strength - Low Plastic Soils

$V_{(w)}$=3.0 %,I_p=12.0,Energy=600-1200kPa,Conf.Stress=138 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1667.74	284.53	167.52
10.25	1818.92	1681.84	285.10	167.45
10.50	1820.77	1694.21	285.49	167.24
10.75	1821.98	1705.03	285.72	166.89
11.00	1822.59	1714.42	285.78	166.41
11.25	1822.65	1722.50	285.69	165.81
11.50	1822.18	1729.40	285.43	165.09
11.75	1821.24	1735.19	285.01	164.27
12.00	1819.84	1739.97	284.45	163.33
12.25	1818.01	1743.82	283.73	162.30
12.50	1815.79	1746.80	282.86	161.16
12.75	1813.19	1748.98	281.84	159.92
13.00	1810.24	1750.42	280.68	158.59
13.25	1806.96	1751.17	279.37	157.17
13.50	1803.36	1751.28	277.92	155.65
13.75	1799.47	1750.78	276.34	154.03
14.00	1795.29	1749.72	274.61	152.32
14.25	1790.85	1748.13	272.74	150.51
14.50	1786.16	1746.03	270.74	148.61
14.75	1781.23	1743.47	268.60	146.60
15.00	1776.07	1736.99	266.33	143.89
15.25	1770.70	1729.92	263.93	141.03
15.50	1765.13	1722.59	261.40	138.07
15.75	1759.36	1715.00	258.73	135.03
16.00	1753.41	1707.18	255.94	131.88
16.25	1747.28	1699.13	253.01	128.63
16.50	1740.98	1690.87	249.96	125.27
16.75	1734.52	1682.40	246.79	121.80
17.00	1727.91	1673.73	243.48	118.22
17.25	1721.15	1664.88	240.05	114.51
17.50	1714.25	1655.84	236.50	110.68
17.75	1707.21	1646.64	232.82	106.72
18.00	1700.05	1637.27	229.02	102.63
18.25	1692.76	1627.75	225.10	98.39
18.50	1685.36	1618.07	221.06	94.01
18.75	1677.84	1608.25	216.89	89.47
19.00	1670.21	1598.28	212.61	84.77
19.25	1662.48	1588.19	208.20	79.90
19.50	1654.65	1577.96	203.67	74.86

Table 5.8

Strength - Low Plastic Soils

$V_{(w)}$=0.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress=276 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1747.39	286.26	173.15
10.25	1818.92	1754.71	288.36	180.92
10.50	1820.77	1760.95	290.25	187.95
10.75	1821.98	1766.19	291.94	194.25
11.00	1822.59	1770.51	293.42	199.84
11.25	1822.65	1773.96	294.71	204.71
11.50	1822.18	1776.61	295.81	208.89
11.75	1821.24	1778.51	296.71	212.39
12.00	1819.84	1779.71	297.44	214.23
12.25	1818.01	1780.25	297.98	214.15
12.50	1815.79	1780.17	298.34	213.72
12.75	1813.19	1779.49	298.53	212.96
13.00	1810.24	1778.25	298.54	211.91
13.25	1806.96	1776.48	298.38	210.59
13.50	1803.36	1774.19	298.06	209.02
13.75	1799.47	1771.40	297.57	207.22
14.00	1795.29	1768.13	296.92	205.21
14.25	1790.85	1764.40	296.10	203.00
14.50	1786.16	1760.22	295.12	200.61
14.75	1781.23	1755.01	293.99	197.94
15.00	1776.07	1749.28	292.70	195.07
15.25	1770.70	1743.19	291.25	192.05
15.50	1765.13	1736.75	289.65	188.88
15.75	1759.36	1729.99	287.90	185.57
16.00	1753.41	1722.93	286.00	182.13
16.25	1747.28	1715.59	283.95	178.57
16.50	1740.98	1707.97	281.76	174.89
16.75	1734.52	1700.11	279.41	171.09
17.00	1727.91	1692.01	276.92	167.18
17.25	1721.15	1683.69	274.29	163.17
17.50	1714.25	1675.16	271.51	159.05
17.75	1707.21	1666.43	268.60	154.82
18.00	1700.05	1657.51	265.54	150.49
18.25	1692.76	1648.41	262.34	146.05
18.50	1685.36	1639.13	259.00	141.51
18.75	1677.84	1629.70	255.52	136.86
19.00	1670.21	1620.10	251.90	132.11
19.25	1662.48	1610.36	248.15	127.25
19.50	1654.65	1600.48	244.26	122.27

Table 5.9

Strength - Low Plastic Soils

$V_{(w)}$=1.5 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress=276 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1723.60	286.26	147.42
10.25	1818.92	1732.87	288.36	156.86
10.50	1820.77	1740.90	290.25	165.59
10.75	1821.98	1747.78	291.94	173.62
11.00	1822.59	1753.60	293.42	180.97
11.25	1822.65	1758.44	294.71	187.63
11.50	1822.18	1762.37	295.81	193.63
11.75	1821.24	1765.45	296.71	198.97
12.00	1819.84	1767.76	297.44	203.66
12.25	1818.01	1769.33	297.98	205.95
12.50	1815.79	1770.22	298.34	204.88
12.75	1813.19	1770.47	298.53	203.60
13.00	1810.24	1770.12	298.54	202.13
13.25	1806.96	1769.19	298.38	200.48
13.50	1803.36	1767.74	298.06	198.66
13.75	1799.47	1765.76	297.57	196.68
14.00	1795.29	1763.30	296.92	194.55
14.25	1790.85	1760.37	296.10	192.29
14.50	1786.16	1756.99	295.12	189.89
14.75	1781.23	1751.86	293.99	187.08
15.00	1776.07	1745.60	292.70	183.98
15.25	1770.70	1739.01	291.25	180.77
15.50	1765.13	1732.13	289.65	177.43
15.75	1759.36	1724.95	287.90	173.99
16.00	1753.41	1717.51	286.00	170.43
16.25	1747.28	1709.82	283.95	166.78
16.50	1740.98	1701.89	281.76	163.02
16.75	1734.52	1693.73	279.41	159.16
17.00	1727.91	1685.36	276.92	155.20
17.25	1721.15	1676.79	274.29	151.15
17.50	1714.25	1668.02	271.51	146.99
17.75	1707.21	1659.07	268.60	142.73
18.00	1700.05	1649.94	265.54	138.38
18.25	1692.76	1640.64	262.34	133.92
18.50	1685.36	1631.18	259.00	129.35
18.75	1677.84	1621.57	255.52	124.68
19.00	1670.21	1611.81	251.90	119.90
19.25	1662.48	1601.91	248.15	115.01
19.50	1654.65	1591.87	244.26	110.01

Table 5.10

Strength - Low Plastic Soils

$V_{(w)}$=3.0 %, I_p=12.0, Energy=600-1200kPa, Conf.Stress=276 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
10.00	1816.38	1667.74	286.26	97.03
10.25	1818.92	1681.84	288.36	108.88
10.50	1820.77	1694.21	290.25	120.01
10.75	1821.98	1705.03	291.94	130.44
11.00	1822.59	1714.42	293.42	140.19
11.25	1822.65	1722.50	294.71	149.27
11.50	1822.18	1729.40	295.81	157.70
11.75	1821.24	1735.19	296.71	165.49
12.00	1819.84	1739.97	297.44	172.66
12.25	1818.01	1743.82	297.98	179.21
12.50	1815.79	1746.80	298.34	184.55
12.75	1813.19	1748.98	298.53	183.31
13.00	1810.24	1750.42	298.54	181.93
13.25	1806.96	1751.17	298.38	180.41
13.50	1803.36	1751.28	298.06	178.78
13.75	1799.47	1750.78	297.57	177.02
14.00	1795.29	1749.72	296.92	175.14
14.25	1790.85	1748.13	296.10	173.15
14.50	1786.16	1746.03	295.12	171.05
14.75	1781.23	1743.47	293.99	168.83
15.00	1776.07	1736.99	292.70	165.69
15.25	1770.70	1729.92	291.25	162.38
15.50	1765.13	1722.59	289.65	158.98
15.75	1759.36	1715.00	287.90	155.48
16.00	1753.41	1707.18	286.00	151.90
16.25	1747.28	1699.13	283.95	148.22
16.50	1740.98	1690.87	281.76	144.45
16.75	1734.52	1682.40	279.41	140.58
17.00	1727.91	1673.73	276.92	136.62
17.25	1721.15	1664.88	274.29	132.56
17.50	1714.25	1655.84	271.51	128.40
17.75	1707.21	1646.64	268.60	124.14
18.00	1700.05	1637.27	265.54	119.78
18.25	1692.76	1627.75	262.34	115.30
18.50	1685.36	1618.07	259.00	110.72
18.75	1677.84	1608.25	255.52	106.03
19.00	1670.21	1598.28	251.90	101.21
19.25	1662.48	1588.19	248.15	96.27
19.50	1654.65	1577.96	244.26	91.21

Table 5.11

Volume change on soaking - Low Plastic Soils

$V_{(w)}$=0.5 %, I_p=9.0, Energy=600-1200kPa, Conf.Stress=20 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1856.48	0.0093	0.1012
12.25	1892.62	1857.95	0.0121	0.1011
12.50	1891.95	1858.80	0.0149	0.1018
12.75	1890.90	1859.09	0.0177	0.1028
13.00	1889.51	1858.86	0.0205	0.1050
13.25	1887.78	1858.15	0.0233	0.1084
13.50	1885.73	1856.99	0.0261	0.1120
13.75	1883.39	1855.43	0.0289	0.1159
14.00	1880.77	1853.50	0.0317	0.1201
14.25	1877.89	1851.22	0.0345	0.1245
14.50	1874.75	1848.61	0.0373	0.1292
14.75	1871.37	1845.72	0.0401	0.1340
15.00	1867.77	1842.54	0.0429	0.1390
15.25	1863.96	1839.10	0.0457	0.1442
15.50	1859.94	1835.41	0.0486	0.1495
15.75	1855.72	1831.49	0.0514	0.1549
16.00	1851.32	1827.35	0.0542	0.1605
16.25	1846.74	1822.99	0.0570	0.1661
16.50	1842.00	1818.42	0.0598	0.1719
16.75	1837.09	1813.65	0.0626	0.1777
17.00	1832.04	1808.48	0.0654	0.1837
17.25	1826.83	1803.07	0.0682	0.1899
17.50	1821.48	1797.44	0.0710	0.1960
17.75	1816.00	1791.61	0.0739	0.2023
18.00	1810.40	1785.57	0.0767	0.2086
18.25	1804.66	1779.33	0.0795	0.2150
18.50	1798.81	1772.90	0.0823	0.2215
18.75	1792.85	1766.27	0.0851	0.2280
19.00	1786.78	1759.45	0.0879	0.2346
19.25	1780.60	1752.45	0.0908	0.2412
19.50	1774.32	1745.27	0.0936	0.2478
19.75	1767.95	1737.92	0.0964	0.2545
20.00	1761.48	1730.40	0.0992	0.2613

Table 5.12

Volume Change on Soaking - Low Plastic Soils

$V_{(w)}$=1.5 %, I_p=9.0, Energy=600-1200kPa, Conf.Stress=20 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1846.87	0.0093	0.1220
12.25	1892.62	1849.45	0.0121	0.1191
12.50	1891.95	1851.32	0.0149	0.1167
12.75	1890.90	1852.52	0.0177	0.1146
13.00	1889.51	1853.10	0.0205	0.1157
13.25	1887.78	1853.11	0.0233	0.1203
13.50	1885.73	1852.59	0.0261	0.1251
13.75	1883.39	1851.58	0.0289	0.1301
14.00	1880.77	1850.12	0.0317	0.1353
14.25	1877.89	1848.26	0.0345	0.1406
14.50	1874.75	1846.01	0.0373	0.1461
14.75	1871.37	1843.41	0.0401	0.1517
15.00	1867.77	1840.50	0.0429	0.1574
15.25	1863.96	1837.29	0.0457	0.1632
15.50	1859.94	1833.80	0.0486	0.1691
15.75	1855.72	1830.06	0.0514	0.1751
16.00	1851.32	1826.09	0.0542	0.1811
16.25	1846.74	1821.89	0.0570	0.1872
16.50	1842.00	1817.48	0.0598	0.1934
16.75	1837.09	1812.70	0.0626	0.1996
17.00	1832.04	1807.21	0.0654	0.2061
17.25	1826.83	1801.50	0.0682	0.2127
17.50	1821.48	1795.57	0.0710	0.2193
17.75	1816.00	1789.42	0.0739	0.2259
18.00	1810.40	1783.07	0.0767	0.2326
18.25	1804.66	1776.51	0.0795	0.2393
18.50	1798.81	1769.76	0.0823	0.2461
18.75	1792.85	1762.82	0.0851	0.2529
19.00	1786.78	1755.70	0.0879	0.2597
19.25	1780.60	1748.40	0.0908	0.2665
19.50	1774.32	1740.94	0.0936	0.2734
19.75	1767.95	1733.31	0.0964	0.2803
20.00	1761.48	1725.53	0.0992	0.2872

Table 5.13

Volume Change on Soaking - Low Plastic Soils

$V_{(w)}$=3.0 %, I_p=9.0, Energy=600-1200kPa, Conf.Stress=20 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1821.39	0.0093	0.1627
12.25	1892.62	1826.53	0.0121	0.1580
12.50	1891.95	1830.76	0.0149	0.1537
12.75	1890.90	1834.14	0.0177	0.1499
13.00	1889.51	1836.72	0.0205	0.1464
13.25	1887.78	1838.56	0.0233	0.1511
13.50	1885.73	1839.72	0.0261	0.1565
13.75	1883.39	1840.23	0.0289	0.1619
14.00	1880.77	1840.14	0.0317	0.1675
14.25	1877.89	1839.50	0.0345	0.1733
14.50	1874.75	1838.34	0.0373	0.1791
14.75	1871.37	1836.70	0.0401	0.1851
15.00	1867.77	1834.63	0.0429	0.1912
15.25	1863.96	1832.14	0.0457	0.1973
15.50	1859.94	1829.29	0.0486	0.2035
15.75	1855.72	1826.09	0.0514	0.2097
16.00	1851.32	1822.58	0.0542	0.2160
16.25	1846.74	1818.79	0.0570	0.2224
16.50	1842.00	1814.67	0.0598	0.2288
16.75	1837.09	1808.94	0.0626	0.2358
17.00	1832.04	1802.98	0.0654	0.2428
17.25	1826.83	1796.80	0.0682	0.2498
17.50	1821.48	1790.40	0.0710	0.2568
17.75	1816.00	1783.80	0.0739	0.2639
18.00	1810.40	1777.01	0.0767	0.2710
18.25	1804.66	1770.03	0.0795	0.2780
18.50	1798.81	1762.86	0.0823	0.2851
18.75	1792.85	1755.53	0.0851	0.2922
19.00	1786.78	1748.02	0.0879	0.2993
19.25	1780.60	1740.37	0.0908	0.3064
19.50	1774.32	1732.56	0.0936	0.3135
19.75	1767.95	1724.60	0.0964	0.3206
20.00	1761.48	1716.50	0.0992	0.3277

Table 5.14

Volume Change on Soaking - Low Plastic Soils

$V_{(w)}$=0.5 %,I_p=9.0,Energy=600-1200kPa,Conf.Stress=30 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1856.48	0.0351	0.1467
12.25	1892.62	1857.95	0.0379	0.1468
12.50	1891.95	1858.80	0.0407	0.1472
12.75	1890.90	1859.09	0.0435	0.1477
13.00	1889.51	1858.86	0.0463	0.1484
13.25	1887.78	1858.15	0.0491	0.1492
13.50	1885.73	1856.99	0.0519	0.1516
13.75	1883.39	1855.43	0.0547	0.1542
14.00	1880.77	1853.50	0.0575	0.1571
14.25	1877.89	1851.22	0.0603	0.1601
14.50	1874.75	1848.61	0.0631	0.1633
14.75	1871.37	1845.72	0.0659	0.1666
15.00	1867.77	1842.54	0.0687	0.1701
15.25	1863.96	1839.10	0.0715	0.1738
15.50	1859.94	1835.41	0.0744	0.1776
15.75	1855.72	1831.49	0.0772	0.1815
16.00	1851.32	1827.35	0.0800	0.1855
16.25	1846.74	1822.99	0.0828	0.1897
16.50	1842.00	1818.42	0.0856	0.1940
16.75	1837.09	1813.65	0.0884	0.1984
17.00	1832.04	1808.48	0.0912	0.2031
17.25	1826.83	1803.07	0.0941	0.2079
17.50	1821.48	1797.44	0.0969	0.2128
17.75	1816.00	1791.61	0.0997	0.2178
18.00	1810.40	1785.57	0.1025	0.2229
18.25	1804.66	1779.33	0.1053	0.2282
18.50	1798.81	1772.90	0.1082	0.2335
18.75	1792.85	1766.27	0.1110	0.2389
19.00	1786.78	1759.45	0.1138	0.2445
19.25	1780.60	1752.45	0.1166	0.2501
19.50	1774.32	1745.27	0.1195	0.2558
19.75	1767.95	1737.92	0.1223	0.2616
20.00	1761.48	1730.40	0.1251	0.2675

Table 5.15

Volume Change on Soaking - Low Plastic Soils

$V_{(w)}$=1.5 %, I_p=9.0, Energy=600-1200kPa, Conf.Stress=30 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1846.87	0.0351	0.1627
12.25	1892.62	1849.45	0.0379	0.1598
12.50	1891.95	1851.32	0.0407	0.1582
12.75	1890.90	1852.52	0.0435	0.1576
13.00	1889.51	1853.10	0.0463	0.1572
13.25	1887.78	1853.11	0.0491	0.1582
13.50	1885.73	1852.59	0.0519	0.1617
13.75	1883.39	1851.58	0.0547	0.1653
14.00	1880.77	1850.12	0.0575	0.1691
14.25	1877.89	1848.26	0.0603	0.1731
14.50	1874.75	1846.01	0.0631	0.1771
14.75	1871.37	1843.41	0.0659	0.1814
15.00	1867.77	1840.50	0.0687	0.1857
15.25	1863.96	1837.29	0.0715	0.1901
15.50	1859.94	1833.80	0.0744	0.1947
15.75	1855.72	1830.06	0.0772	0.1993
16.00	1851.32	1826.09	0.0800	0.2040
16.25	1846.74	1821.89	0.0828	0.2088
16.50	1842.00	1817.48	0.0856	0.2136
16.75	1837.09	1812.70	0.0884	0.2186
17.00	1832.04	1807.21	0.0912	0.2240
17.25	1826.83	1801.50	0.0941	0.2294
17.50	1821.48	1795.57	0.0969	0.2350
17.75	1816.00	1789.42	0.0997	0.2406
18.00	1810.40	1783.07	0.1025	0.2463
18.25	1804.66	1776.51	0.1053	0.2520
18.50	1798.81	1769.76	0.1082	0.2578
18.75	1792.85	1762.82	0.1110	0.2637
19.00	1786.78	1755.70	0.1138	0.2696
19.25	1780.60	1748.40	0.1166	0.2756
19.50	1774.32	1740.94	0.1195	0.2817
19.75	1767.95	1733.31	0.1223	0.2878
20.00	1761.48	1725.53	0.1251	0.2939

Table 5.16

Volume Change on Soaking - Low Plastic Soils

$V_{(w)}$=3.0 %,I_p=9.0,Energy=600-1200kPa,Conf.Stress=30 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1892.89	1821.39	0.0351	0.2043
12.25	1892.62	1826.53	0.0379	0.1994
12.50	1891.95	1830.76	0.0407	0.1949
12.75	1890.90	1834.14	0.0435	0.1910
13.00	1889.51	1836.72	0.0463	0.1873
13.25	1887.78	1838.56	0.0491	0.1865
13.50	1885.73	1839.72	0.0519	0.1904
13.75	1883.39	1840.23	0.0547	0.1944
14.00	1880.77	1840.14	0.0575	0.1987
14.25	1877.89	1839.50	0.0603	0.2030
14.50	1874.75	1838.34	0.0631	0.2076
14.75	1871.37	1836.70	0.0659	0.2122
15.00	1867.77	1834.63	0.0687	0.2170
15.25	1863.96	1832.14	0.0715	0.2219
15.50	1859.94	1829.29	0.0744	0.2269
15.75	1855.72	1826.09	0.0772	0.2319
16.00	1851.32	1822.58	0.0800	0.2370
16.25	1846.74	1818.79	0.0828	0.2422
16.50	1842.00	1814.67	0.0856	0.2475
16.75	1837.09	1808.94	0.0884	0.2536
17.00	1832.04	1802.98	0.0912	0.2597
17.25	1826.83	1796.80	0.0941	0.2659
17.50	1821.48	1790.40	0.0969	0.2721
17.75	1816.00	1783.80	0.0997	0.2783
18.00	1810.40	1777.01	0.1025	0.2846
18.25	1804.66	1770.03	0.1053	0.2909
18.50	1798.81	1762.86	0.1082	0.2972
18.75	1792.85	1755.53	0.1110	0.3035
19.00	1786.78	1748.02	0.1138	0.3099
19.25	1780.60	1740.37	0.1166	0.3163
19.50	1774.32	1732.56	0.1195	0.3226
19.75	1767.95	1724.60	0.1223	0.3291
20.00	1761.48	1716.50	0.1251	0.3355

Table 5.17

Pre-Stress - Low Plastic Soils

$V_{(w)}$=0.5%, I_p=12.00, Energy Input= 600.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	49.20	44.53
9.75	48.68	44.09
10.00	48.16	43.65
10.25	47.65	43.21
10.50	47.14	42.77
10.75	46.64	42.32
11.00	46.14	41.88
11.25	45.64	41.43
11.50	45.15	40.98
11.75	44.67	40.52
12.00	44.19	40.06
12.25	43.71	39.61
12.50	43.24	39.13
12.75	42.77	38.65
13.00	42.30	38.16
13.25	41.84	37.68
13.50	41.39	37.19
13.75	40.94	36.70
14.00	40.49	36.22
14.25	40.04	35.73
14.50	39.61	35.24
14.75	39.17	34.76
15.00	38.74	34.28
15.25	38.32	33.79
15.50	37.89	33.32
15.75	37.48	32.84
16.00	37.06	32.36
16.25	36.66	31.89
16.50	36.25	31.42
16.75	35.85	30.95
17.00	35.46	30.49
17.25	35.06	30.03
17.50	34.68	29.57
17.75	34.30	29.12
18.00	33.92	28.67
18.25	33.54	28.22
18.50	33.17	27.78
18.75	32.81	27.34
19.00	32.45	26.90

Table 5.18

Pre-Stress - Low Plastic Soils

$V_{(w)}$=1.5%, I_p=12.00, Energy Input= 600.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	49.20	44.13
9.75	48.68	43.72
10.00	48.16	43.31
10.25	47.65	42.89
10.50	47.14	42.47
10.75	46.64	42.05
11.00	46.14	41.63
11.25	45.64	41.21
11.50	45.15	40.78
11.75	44.67	40.36
12.00	44.19	39.92
12.25	43.71	39.49
12.50	43.24	39.04
12.75	42.77	38.53
13.00	42.30	38.03
13.25	41.84	37.53
13.50	41.39	37.02
13.75	40.94	36.52
14.00	40.49	36.02
14.25	40.04	35.52
14.50	39.61	35.03
14.75	39.17	34.53
15.00	38.74	34.04
15.25	38.32	33.55
15.50	37.89	33.06
15.75	37.48	32.58
16.00	37.06	32.10
16.25	36.66	31.62
16.50	36.25	31.14
16.75	35.85	30.67
17.00	35.46	30.21
17.25	35.06	29.74
17.50	34.68	29.28
17.75	34.30	28.83
18.00	33.92	28.38
18.25	33.54	27.93
18.50	33.17	27.49
18.75	32.81	27.05
19.00	32.45	26.61

Table 5.19

Pre-Stress - Low Plastic Soils

$V_{(w)}$=3.0%, I_p=12.00, Energy Input= 600.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	49.20	43.38
9.75	48.68	43.00
10.00	48.16	42.61
10.25	47.65	42.23
10.50	47.14	41.85
10.75	46.64	41.46
11.00	46.14	41.08
11.25	45.64	40.69
11.50	45.15	40.30
11.75	44.67	39.91
12.00	44.19	39.52
12.25	43.71	39.12
12.50	43.24	38.73
12.75	42.77	38.25
13.00	42.30	37.72
13.25	41.84	37.20
13.50	41.39	36.68
13.75	40.94	36.17
14.00	40.49	35.66
14.25	40.04	35.15
14.50	39.61	34.64
14.75	39.17	34.13
15.00	38.74	33.63
15.25	38.32	33.14
15.50	37.89	32.64
15.75	37.48	32.16
16.00	37.06	31.67
16.25	36.66	31.19
16.50	36.25	30.71
16.75	35.85	30.24
17.00	35.46	29.77
17.25	35.06	29.30
17.50	34.68	28.84
17.75	34.30	28.39
18.00	33.92	27.94
18.25	33.54	27.49
18.50	33.17	27.05
18.75	32.81	26.61
19.00	32.45	26.18

Table 5.20

Pre-Stress - Low Plastic Soils

$V_{(w)}$=0.5%, I_p= 8.00, Energy Input=1000.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	31.36	28.65
9.75	31.07	28.45
10.00	30.79	28.25
10.25	30.52	28.06
10.50	30.25	27.88
10.75	30.00	27.70
11.00	29.74	27.52
11.25	29.50	27.35
11.50	29.26	27.18
11.75	29.03	27.02
12.00	28.81	26.87
12.25	28.59	26.71
12.50	28.38	26.57
12.75	28.18	26.43
13.00	27.99	26.29
13.25	27.80	26.16
13.50	27.62	26.04
13.75	27.45	25.92
14.00	27.28	25.80
14.25	27.12	25.69
14.50	26.97	25.58
14.75	26.82	25.48
15.00	26.69	25.38
15.25	26.56	25.29
15.50	26.43	25.20
15.75	26.32	25.11
16.00	26.21	25.03
16.25	26.11	24.94
16.50	26.01	24.86
16.75	25.93	24.77
17.00	25.85	24.67
17.25	25.77	24.57
17.50	25.71	24.47
17.75	25.65	24.38
18.00	25.60	24.28
18.25	25.55	24.19
18.50	25.52	24.10
18.75	25.49	24.01
19.00	25.47	23.92

Table 5.21

Pre-Stress - Low Plastic Soils

$V_{(w)}$=1.5%, I_p= 8.00, Energy Input=1000.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	31.36	28.28
9.75	31.07	28.09
10.00	30.79	27.90
10.25	30.52	27.72
10.50	30.25	27.54
10.75	30.00	27.37
11.00	29.74	27.20
11.25	29.50	27.04
11.50	29.26	26.88
11.75	29.03	26.73
12.00	28.81	26.58
12.25	28.59	26.44
12.50	28.38	26.30
12.75	28.18	26.17
13.00	27.99	26.04
13.25	27.80	25.92
13.50	27.62	25.81
13.75	27.45	25.69
14.00	27.28	25.59
14.25	27.12	25.48
14.50	26.97	25.39
14.75	26.82	25.30
15.00	26.69	25.21
15.25	26.56	25.13
15.50	26.43	25.05
15.75	26.32	24.97
16.00	26.21	24.91
16.25	26.11	24.84
16.50	26.01	24.78
16.75	25.93	24.65
17.00	25.85	24.53
17.25	25.77	24.41
17.50	25.71	24.29
17.75	25.65	24.17
18.00	25.60	24.06
18.25	25.55	23.95
18.50	25.52	23.84
18.75	25.49	23.73
19.00	25.47	23.63

Table 5.22

Pre-Stress - Low Plastic Soils

$V_{(w)}$=3.0%, I_p= 8.00, Energy Input=1000.0 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
9.50	31.36	27.64
9.75	31.07	27.47
10.00	30.79	27.30
10.25	30.52	27.13
10.50	30.25	26.97
10.75	30.00	26.81
11.00	29.74	26.66
11.25	29.50	26.51
11.50	29.26	26.37
11.75	29.03	26.23
12.00	28.81	26.09
12.25	28.59	25.97
12.50	28.38	25.84
12.75	28.18	25.72
13.00	27.99	25.61
13.25	27.80	25.50
13.50	27.62	25.39
13.75	27.45	25.29
14.00	27.28	25.20
14.25	27.12	25.11
14.50	26.97	25.03
14.75	26.82	24.95
15.00	26.69	24.87
15.25	26.56	24.81
15.50	26.43	24.74
15.75	26.32	24.68
16.00	26.21	24.63
16.25	26.11	24.58
16.50	26.01	24.47
16.75	25.93	24.32
17.00	25.85	24.17
17.25	25.77	24.02
17.50	25.71	23.87
17.75	25.65	23.73
18.00	25.60	23.58
18.25	25.55	23.45
18.50	25.52	23.31
18.75	25.49	23.19
19.00	25.47	23.06

Table 5.23

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=0.5%, I_p=10.0, Energy= 600.0kPa, Conf.Str.= 40.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	102.53	79.94
10.25	101.68	79.49
10.50	100.84	79.04
10.75	100.02	78.58
11.00	99.21	78.11
11.25	98.42	77.63
11.50	97.64	77.15
11.75	96.88	76.65
12.00	96.13	76.15
12.25	95.39	75.64
12.50	94.67	75.12
12.75	93.96	74.60
13.00	93.27	74.06
13.25	92.60	73.52
13.50	91.93	72.97
13.75	91.28	72.41
14.00	90.65	71.85
14.25	90.03	71.28
14.50	89.43	70.63
14.75	88.84	69.98
15.00	88.26	69.32
15.25	87.70	68.67
15.50	87.15	68.01
15.75	86.62	67.36
16.00	86.10	66.71
16.25	85.60	66.06
16.50	85.11	65.42
16.75	84.63	64.78
17.00	84.17	64.14
17.25	83.73	63.52
17.50	83.29	62.89
17.75	82.88	62.28
18.00	82.47	61.67
18.25	82.09	61.07
18.50	81.71	60.48
18.75	81.35	59.90
19.00	81.01	59.33
19.25	80.68	58.77
19.50	80.36	58.23

Table 5.24

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=1.5%,I_p=10.0,Energy= 600.0kPa,Conf.Str.= 40.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	102.53	78.11
10.25	101.68	77.75
10.50	100.84	77.38
10.75	100.02	77.00
11.00	99.21	76.62
11.25	98.42	76.23
11.50	97.64	75.84
11.75	96.88	75.43
12.00	96.13	75.02
12.25	95.39	74.60
12.50	94.67	74.18
12.75	93.96	73.74
13.00	93.27	73.30
13.25	92.60	72.85
13.50	91.93	72.39
13.75	91.28	71.92
14.00	90.65	71.44
14.25	90.03	70.96
14.50	89.43	70.29
14.75	88.84	69.58
15.00	88.26	68.87
15.25	87.70	68.16
15.50	87.15	67.46
15.75	86.62	66.77
16.00	86.10	66.07
16.25	85.60	65.39
16.50	85.11	64.71
16.75	84.63	64.03
17.00	84.17	63.37
17.25	83.73	62.71
17.50	83.29	62.06
17.75	82.88	61.43
18.00	82.47	60.80
18.25	82.09	60.18
18.50	81.71	59.58
18.75	81.35	58.98
19.00	81.01	58.40
19.25	80.68	57.83
19.50	80.36	57.28

Table 5.25

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=3.0%,I_p=10.0,Energy= 600.0kPa,Conf.Str.= 40.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	102.53	74.80
10.25	101.68	74.55
10.50	100.84	74.29
10.75	100.02	74.03
11.00	99.21	73.77
11.25	98.42	73.50
11.50	97.64	73.23
11.75	96.88	72.95
12.00	96.13	72.67
12.25	95.39	72.38
12.50	94.67	72.08
12.75	93.96	71.78
13.00	93.27	71.47
13.25	92.60	71.15
13.50	91.93	70.83
13.75	91.28	70.50
14.00	90.65	70.16
14.25	90.03	69.81
14.50	89.43	69.40
14.75	88.84	68.63
15.00	88.26	67.86
15.25	87.70	67.10
15.50	87.15	66.35
15.75	86.62	65.60
16.00	86.10	64.87
16.25	85.60	64.15
16.50	85.11	63.43
16.75	84.63	62.73
17.00	84.17	62.04
17.25	83.73	61.36
17.50	83.29	60.69
17.75	82.88	60.03
18.00	82.47	59.39
18.25	82.09	58.76
18.50	81.71	58.14
18.75	81.35	57.54
19.00	81.01	56.95
19.25	80.68	56.38
19.50	80.36	55.82

Table 5.26

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=0.5%, I_p= 8.0, Energy=1000.0kPa, Conf.Str.= 20.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	57.45	45.69
10.25	57.13	45.75
10.50	56.83	45.82
10.75	56.56	45.90
11.00	56.31	45.99
11.25	56.09	46.10
11.50	55.89	46.21
11.75	55.71	46.34
12.00	55.56	46.48
12.25	55.43	46.63
12.50	55.33	46.79
12.75	55.25	46.96
13.00	55.20	47.14
13.25	55.17	47.33
13.50	55.16	47.53
13.75	55.18	47.73
14.00	55.22	47.95
14.25	55.28	48.17
14.50	55.37	48.40
14.75	55.48	48.64
15.00	55.62	48.88
15.25	55.78	49.13
15.50	55.97	49.38
15.75	56.18	49.60
16.00	56.41	49.77
16.25	56.67	49.94
16.50	56.95	50.12
16.75	57.26	50.29
17.00	57.59	50.47
17.25	57.94	50.65
17.50	58.32	50.84
17.75	58.72	51.03
18.00	59.15	51.22
18.25	59.60	51.42
18.50	60.08	51.62
18.75	60.57	51.83
19.00	61.10	52.05
19.25	61.64	52.27
19.50	62.22	52.50

Table 5.27

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=1.5%, I_p= 8.0, Energy=1000.0kPa, Conf.Str.= 20.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	57.45	44.05
10.25	57.13	44.16
10.50	56.83	44.28
10.75	56.56	44.41
11.00	56.31	44.55
11.25	56.09	44.71
11.50	55.89	44.88
11.75	55.71	45.05
12.00	55.56	45.24
12.25	55.43	45.44
12.50	55.33	45.66
12.75	55.25	45.88
13.00	55.20	46.11
13.25	55.17	46.36
13.50	55.16	46.62
13.75	55.18	46.88
14.00	55.22	47.16
14.25	55.28	47.44
14.50	55.37	47.74
14.75	55.48	48.04
15.00	55.62	48.36
15.25	55.78	48.68
15.50	55.97	49.00
15.75	56.18	49.21
16.00	56.41	49.29
16.25	56.67	49.38
16.50	56.95	49.47
16.75	57.26	49.56
17.00	57.59	49.66
17.25	57.94	49.76
17.50	58.32	49.87
17.75	58.72	49.98
18.00	59.15	50.10
18.25	59.60	50.22
18.50	60.08	50.36
18.75	60.57	50.50
19.00	61.10	50.65
19.25	61.64	50.80
19.50	62.22	50.97

Table 5.28

Soaked Pre-Stress - Low Plastic Soils

$V_{(w)}$=3.0%, I_p= 8.0, Energy=1000.0kPa, Conf.Str.= 20.0kPa

Water Content (%)	Expected Soaked Pre-Stress (kPa)	Expected Min Soaked Pre-Stress (kPa)
10.00	57.45	41.20
10.25	57.13	41.39
10.50	56.83	41.59
10.75	56.56	41.80
11.00	56.31	42.02
11.25	56.09	42.25
11.50	55.89	42.49
11.75	55.71	42.74
12.00	55.56	43.01
12.25	55.43	43.29
12.50	55.33	43.57
12.75	55.25	43.87
13.00	55.20	44.18
13.25	55.17	44.51
13.50	55.16	44.84
13.75	55.18	45.19
14.00	55.22	45.54
14.25	55.28	45.91
14.50	55.37	46.29
14.75	55.48	46.68
15.00	55.62	47.08
15.25	55.78	47.49
15.50	55.97	47.91
15.75	56.18	48.00
16.00	56.41	47.96
16.25	56.67	47.93
16.50	56.95	47.90
16.75	57.26	47.88
17.00	57.59	47.87
17.25	57.94	47.87
17.50	58.32	47.87
17.75	58.72	47.88
18.00	59.15	47.90
18.25	59.60	47.93
18.50	60.08	47.97
18.75	60.57	48.01
19.00	61.10	48.07
19.25	61.64	48.13
19.50	62.22	48.20

Table 5.29

Dry Density - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)
12.00	1841.16	1718.73
12.25	1838.20	1728.14
12.50	1835.25	1736.68
12.75	1832.32	1744.40
13.00	1829.41	1751.34
13.25	1826.51	1757.55
13.50	1823.62	1763.05
13.75	1820.74	1767.87
14.00	1817.88	1772.06
14.25	1815.02	1775.62
14.50	1812.18	1778.58
14.75	1809.34	1780.95
15.00	1806.51	1782.74
15.25	1803.69	1783.94
15.50	1800.88	1784.56
15.75	1798.08	1784.56
16.00	1795.28	1783.92
16.25	1792.49	1780.26
16.50	1789.70	1775.98
16.75	1786.92	1771.31
17.00	1784.15	1766.24
17.25	1781.38	1760.79
17.50	1778.61	1754.98
17.75	1775.85	1748.83
18.00	1773.10	1742.36
18.25	1770.35	1735.58
18.50	1767.60	1728.51
18.75	1764.85	1721.15
19.00	1762.11	1713.52
19.25	1759.37	1705.62
19.50	1756.64	1697.46
19.75	1753.90	1689.04
20.00	1751.17	1680.37

Table 5.30

Strength - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1772.46	1685.67	385.26	320.99
12.25	1772.55	1694.93	381.18	320.08
12.50	1772.56	1703.43	376.94	318.80
12.75	1772.51	1711.19	372.53	317.14
13.00	1772.39	1718.25	367.97	315.13
13.25	1772.21	1724.63	363.25	312.78
13.50	1771.98	1730.35	358.37	310.11
13.75	1771.68	1735.43	353.34	307.11
14.00	1771.34	1739.88	348.16	303.81
14.25	1770.94	1743.70	342.83	300.21
14.50	1770.50	1746.89	337.35	296.31
14.75	1770.01	1749.44	331.72	292.12
15.00	1769.48	1751.35	325.94	287.65
15.25	1768.91	1752.64	320.02	282.91
15.50	1768.30	1753.32	313.95	277.90
15.75	1767.65	1753.47	307.75	272.62
16.00	1766.97	1752.82	301.39	267.07
16.25	1766.26	1751.87	294.90	261.28
16.50	1765.51	1750.88	288.27	255.26
16.75	1764.73	1749.83	281.50	248.99
17.00	1763.92	1748.70	274.58	241.78
17.25	1763.09	1747.45	267.53	234.12
17.50	1762.23	1746.03	260.35	226.16
17.75	1761.34	1744.39	253.02	217.89
18.00	1760.42	1742.47	245.56	209.30
18.25	1759.49	1740.24	237.96	200.39
18.50	1758.53	1737.68	230.23	191.17
18.75	1757.55	1734.77	222.37	181.64
19.00	1756.54	1731.52	214.37	171.79
19.25	1755.52	1727.91	206.23	161.64
19.50	1754.48	1723.98	197.97	151.19
19.75	1753.41	1719.73	189.57	140.44
20.00	1752.33	1715.17	181.03	129.42

Table 5.31

Strength - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1772.46	1641.28	385.26	306.02
12.25	1772.55	1653.71	381.18	306.09
12.50	1772.56	1665.21	376.94	305.70
12.75	1772.51	1675.83	372.53	304.90
13.00	1772.39	1685.61	367.97	303.68
13.25	1772.21	1694.60	363.25	302.08
13.50	1771.98	1702.84	358.37	300.11
13.75	1771.68	1710.36	353.34	297.79
14.00	1771.34	1717.19	348.16	295.13
14.25	1770.94	1723.35	342.83	292.14
14.50	1770.50	1728.87	337.35	288.84
14.75	1770.01	1733.76	331.72	285.23
15.00	1769.48	1738.02	325.94	281.32
15.25	1768.91	1741.66	320.02	277.12
15.50	1768.30	1744.69	313.95	272.64
15.75	1767.65	1747.08	307.75	267.88
16.00	1766.97	1748.85	301.39	262.84
16.25	1766.26	1749.98	294.90	257.52
16.50	1765.51	1749.32	288.27	251.83
16.75	1764.73	1747.78	281.50	245.86
17.00	1763.92	1745.97	274.58	237.92
17.25	1763.09	1743.84	267.53	229.53
17.50	1762.23	1741.38	260.35	220.81
17.75	1761.34	1738.57	253.02	211.78
18.00	1760.42	1735.40	245.56	202.44
18.25	1759.49	1731.88	237.96	192.79
18.50	1758.53	1728.03	230.23	182.84
18.75	1757.55	1723.86	222.37	172.60
19.00	1756.54	1719.38	214.37	162.07
19.25	1755.52	1714.60	206.23	151.27
19.50	1754.48	1709.53	197.97	140.20
19.75	1753.41	1704.19	189.57	128.86
20.00	1752.33	1698.58	181.03	117.27

Table 5.32

Strength - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1772.46	1545.76	385.26	274.29
12.25	1772.55	1564.70	381.18	276.50
12.50	1772.56	1582.28	376.94	278.10
12.75	1772.51	1598.60	372.53	279.11
13.00	1772.39	1613.74	367.97	279.58
13.25	1772.21	1627.79	363.25	279.53
13.50	1771.98	1640.80	358.37	279.01
13.75	1771.68	1652.85	353.34	278.04
14.00	1771.34	1663.98	348.16	276.64
14.25	1770.94	1674.25	342.83	274.83
14.50	1770.50	1683.71	337.35	272.64
14.75	1770.01	1692.40	331.72	270.08
15.00	1769.48	1700.34	325.94	267.17
15.25	1768.91	1707.59	320.02	263.93
15.50	1768.30	1714.15	313.95	260.36
15.75	1767.65	1720.06	307.75	256.48
16.00	1766.97	1725.34	301.39	252.30
16.25	1766.26	1730.00	294.90	247.82
16.50	1765.51	1734.05	288.27	243.05
16.75	1764.73	1737.13	281.50	235.52
17.00	1763.92	1733.43	274.58	226.34
17.25	1763.09	1729.40	267.53	216.86
17.50	1762.23	1725.06	260.35	207.10
17.75	1761.34	1720.41	253.02	197.06
18.00	1760.42	1715.48	245.56	186.75
18.25	1759.49	1710.26	237.96	176.18
18.50	1758.53	1704.78	230.23	165.34
18.75	1757.55	1699.03	222.37	154.26
19.00	1756.54	1693.04	214.37	142.93
19.25	1755.52	1686.79	206.23	131.35
19.50	1754.48	1680.31	197.97	119.54
19.75	1753.41	1673.59	189.57	107.50
20.00	1752.33	1666.64	181.03	95.22

Table 5.33

Strength - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1841.16	1763.09	445.85	381.59
12.25	1838.20	1769.24	440.75	378.16
12.50	1835.25	1774.68	435.52	374.44
12.75	1832.32	1779.46	430.16	370.44
13.00	1829.41	1783.59	424.66	366.19
13.25	1826.51	1787.10	419.04	361.70
13.50	1823.62	1790.02	413.29	356.97
13.75	1820.74	1792.35	407.41	352.01
14.00	1817.88	1794.10	401.39	346.85
14.25	1815.02	1795.27	395.25	341.48
14.50	1812.18	1795.85	388.98	335.91
14.75	1809.34	1795.82	382.58	330.14
15.00	1806.51	1795.16	376.05	324.17
15.25	1803.69	1793.84	369.40	318.01
15.50	1800.88	1791.91	362.61	311.65
15.75	1798.08	1788.96	355.69	305.07
16.00	1795.28	1785.96	348.65	298.15
16.25	1792.49	1782.94	341.48	290.96
16.50	1789.70	1779.83	334.18	283.57
16.75	1786.92	1776.56	326.75	275.96
17.00	1784.15	1773.02	319.20	268.12
17.25	1781.38	1769.15	311.51	260.03
17.50	1778.61	1764.90	303.70	251.69
17.75	1775.85	1760.24	295.76	243.08
18.00	1773.10	1755.19	287.70	234.21
18.25	1770.35	1749.76	279.50	225.06
18.50	1767.60	1743.96	271.18	215.63
18.75	1764.85	1737.83	262.74	205.93
19.00	1762.11	1731.38	254.16	195.94
19.25	1759.37	1724.61	245.46	185.68
19.50	1756.64	1717.55	236.63	175.13
19.75	1753.90	1710.20	227.68	164.31
20.00	1751.17	1702.58	218.60	153.22

Table 5.34

Strength - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1841.16	1718.73	445.85	373.52
12.25	1838.20	1728.14	440.75	371.17
12.50	1835.25	1736.68	435.52	368.44
12.75	1832.32	1744.40	430.16	365.33
13.00	1829.41	1751.34	424.66	361.87
13.25	1826.51	1757.55	419.04	357.82
13.50	1823.62	1763.05	413.29	353.47
13.75	1820.74	1767.87	407.41	348.85
14.00	1817.88	1772.06	401.39	343.97
14.25	1815.02	1775.62	395.25	338.86
14.50	1812.18	1778.58	388.98	333.53
14.75	1809.34	1780.95	382.58	327.98
15.00	1806.51	1782.74	376.05	322.22
15.25	1803.69	1783.94	369.40	316.27
15.50	1800.88	1784.56	362.61	310.13
15.75	1798.08	1784.56	355.69	303.40
16.00	1795.28	1783.92	348.65	296.37
16.25	1792.49	1780.26	341.48	288.79
16.50	1789.70	1775.98	334.18	280.92
16.75	1786.92	1771.31	326.75	272.78
17.00	1784.15	1766.24	319.20	264.37
17.25	1781.38	1760.79	311.51	255.68
17.50	1778.61	1754.98	303.70	246.71
17.75	1775.85	1748.83	295.76	237.46
18.00	1773.10	1742.36	287.70	227.93
18.25	1770.35	1735.58	279.50	218.12
18.50	1767.60	1728.51	271.18	208.03
18.75	1764.85	1721.15	262.74	197.67
19.00	1762.11	1713.52	254.16	187.03
19.25	1759.37	1705.62	245.46	176.12
19.50	1756.64	1697.46	236.63	164.94
19.75	1753.90	1689.04	227.68	153.49
20.00	1751.17	1680.37	218.60	141.78

Table 5.35

Strength - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1841.16	1622.39	445.85	348.74
12.25	1838.20	1638.49	440.75	348.31
12.50	1835.25	1653.29	435.52	347.35
12.75	1832.32	1666.88	430.16	345.89
13.00	1829.41	1679.35	424.66	343.95
13.25	1826.51	1690.76	419.04	341.54
13.50	1823.62	1701.18	413.29	338.68
13.75	1820.74	1710.68	407.41	335.38
14.00	1817.88	1719.30	401.39	331.64
14.25	1815.02	1727.10	395.25	327.49
14.50	1812.18	1734.11	388.98	322.93
14.75	1809.34	1740.38	382.58	317.97
15.00	1806.51	1745.94	376.05	312.63
15.25	1803.69	1750.82	369.40	306.90
15.50	1800.88	1755.06	362.61	300.81
15.75	1798.08	1758.67	355.69	294.36
16.00	1795.28	1761.68	348.65	287.56
16.25	1792.49	1764.09	341.48	280.41
16.50	1789.70	1758.97	334.18	271.81
16.75	1786.92	1752.16	326.75	262.70
17.00	1784.15	1745.06	319.20	253.32
17.25	1781.38	1737.68	311.51	243.66
17.50	1778.61	1730.02	303.70	233.73
17.75	1775.85	1722.10	295.76	223.52
18.00	1773.10	1713.92	287.70	213.05
18.25	1770.35	1705.48	279.50	202.32
18.50	1767.60	1696.79	271.18	191.32
18.75	1764.85	1687.86	262.74	180.07
19.00	1762.11	1678.69	254.16	168.56
19.25	1759.37	1669.29	245.46	156.80
19.50	1756.64	1659.64	236.63	144.78
19.75	1753.90	1649.77	227.68	132.53
20.00	1751.17	1639.67	218.60	120.03

Table 5.36

Strength - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1893.13	1818.51	398.56	344.59
12.25	1887.46	1822.02	391.67	341.10
12.50	1881.89	1824.84	384.68	337.29
12.75	1876.41	1827.00	377.60	333.19
13.00	1871.01	1828.50	370.42	328.80
13.25	1865.69	1829.34	363.15	324.13
13.50	1860.44	1829.53	355.77	319.19
13.75	1855.26	1829.04	348.29	313.98
14.00	1850.14	1827.83	340.71	308.50
14.25	1845.09	1825.89	333.02	302.76
14.50	1840.09	1823.17	325.23	296.74
14.75	1835.15	1819.71	317.34	290.46
15.00	1830.26	1815.22	309.34	283.87
15.25	1825.41	1810.14	301.23	277.01
15.50	1820.62	1805.20	293.01	269.98
15.75	1815.87	1800.39	284.68	262.33
16.00	1811.16	1795.71	276.24	254.29
16.25	1806.49	1791.10	267.70	245.94
16.50	1801.86	1786.44	259.04	237.24
16.75	1797.27	1781.76	250.27	228.21
17.00	1792.71	1776.83	241.38	218.78
17.25	1788.18	1771.58	232.39	208.96
17.50	1783.68	1765.91	223.28	198.75
17.75	1779.22	1759.77	214.06	188.16
18.00	1774.78	1753.13	204.73	177.22
18.25	1770.37	1746.01	195.28	165.94
18.50	1765.99	1738.43	185.72	154.36
18.75	1761.63	1730.44	176.04	142.49
19.00	1757.30	1722.04	166.25	130.35
19.25	1752.98	1713.29	156.34	117.95
19.50	1748.70	1704.19	146.31	105.30
19.75	1744.43	1694.76	136.17	92.41
20.00	1740.18	1685.03	125.92	79.28

Table 5.37

Strength - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1893.13	1773.35	398.56	333.85
12.25	1887.46	1780.33	391.67	331.22
12.50	1881.89	1786.47	384.68	328.14
12.75	1876.41	1791.81	377.60	324.70
13.00	1871.01	1796.39	370.42	320.93
13.25	1865.69	1800.24	363.15	316.83
13.50	1860.44	1803.39	355.77	312.42
13.75	1855.26	1805.84	348.29	307.70
14.00	1850.14	1807.63	340.71	302.70
14.25	1845.09	1808.74	333.02	297.41
14.50	1840.09	1809.18	325.23	291.86
14.75	1835.15	1808.93	317.34	286.03
15.00	1830.26	1807.95	309.34	279.96
15.25	1825.41	1806.21	301.23	273.64
15.50	1820.62	1803.70	293.01	266.59
15.75	1815.87	1800.36	284.68	258.49
16.00	1811.16	1795.29	276.24	249.64
16.25	1806.49	1789.89	267.70	240.42
16.50	1801.86	1784.09	259.04	230.80
16.75	1797.27	1777.81	250.27	220.80
17.00	1792.71	1771.05	241.38	210.42
17.25	1788.18	1763.82	232.39	199.70
17.50	1783.68	1756.13	223.28	188.66
17.75	1779.22	1748.02	214.06	177.31
18.00	1774.78	1739.53	204.73	165.67
18.25	1770.37	1730.68	195.28	153.77
18.50	1765.99	1721.48	185.72	141.61
18.75	1761.63	1711.97	176.04	129.20
19.00	1757.30	1702.15	166.25	116.56
19.25	1752.98	1692.03	156.34	103.68
19.50	1748.70	1681.63	146.31	90.57
19.75	1744.43	1670.96	136.17	77.24
20.00	1740.18	1660.01	125.92	63.68

Table 5.38

Strength - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength (kPa)	Expected Minimum Strength (kPa)
12.00	1893.13	1674.47	398.56	303.88
12.25	1887.46	1688.40	391.67	303.20
12.50	1881.89	1701.07	384.68	302.03
12.75	1876.41	1712.55	377.60	300.38
13.00	1871.01	1722.93	370.42	298.25
13.25	1865.69	1732.28	363.15	295.66
13.50	1860.44	1740.66	355.77	292.60
13.75	1855.26	1748.12	348.29	289.07
14.00	1850.14	1754.72	340.71	285.07
14.25	1845.09	1760.49	333.02	280.59
14.50	1840.09	1765.47	325.23	275.62
14.75	1835.15	1769.70	317.34	270.14
15.00	1830.26	1773.20	309.34	264.15
15.25	1825.41	1776.00	301.23	257.64
15.50	1820.62	1778.11	293.01	250.59
15.75	1815.87	1779.52	284.68	243.00
16.00	1811.16	1780.25	276.24	234.89
16.25	1806.49	1775.30	267.70	225.14
16.50	1801.86	1766.61	259.04	214.31
16.75	1797.27	1757.57	250.27	203.20
17.00	1792.71	1748.20	241.38	191.82
17.25	1788.18	1738.52	232.39	180.17
17.50	1783.68	1728.54	223.28	168.28
17.75	1779.22	1718.27	214.06	156.15
18.00	1774.78	1707.72	204.73	143.78
18.25	1770.37	1696.90	195.28	131.18
18.50	1765.99	1685.82	185.72	118.36
18.75	1761.63	1674.49	176.04	105.31
19.00	1757.30	1662.90	166.25	92.04
19.25	1752.98	1651.06	156.34	78.55
19.50	1748.70	1638.98	146.31	64.85
19.75	1744.43	1626.65	136.17	50.93
20.00	1740.18	1614.09	125.92	36.80

Table 5.39

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1772.46	1685.67	0.7241	1.0440
12.25	1772.55	1694.93	0.7102	1.0100
12.50	1772.56	1703.43	0.6969	0.9776
12.75	1772.51	1711.19	0.6839	0.9467
13.00	1772.39	1718.25	0.6713	0.9172
13.25	1772.21	1724.63	0.6590	0.8891
13.50	1771.98	1730.35	0.6471	0.8623
13.75	1771.68	1735.43	0.6355	0.8367
14.00	1771.34	1739.88	0.6243	0.8123
14.25	1770.94	1743.70	0.6133	0.7891
14.50	1770.50	1746.89	0.6026	0.7671
14.75	1770.01	1749.44	0.5921	0.7463
15.00	1769.48	1751.35	0.5819	0.7268
15.25	1768.91	1752.64	0.5720	0.7085
15.50	1768.30	1753.32	0.5622	0.6915
15.75	1767.65	1753.47	0.5527	0.6757
16.00	1766.97	1752.82	0.5434	0.6615
16.25	1766.26	1751.87	0.5343	0.6484
16.50	1765.51	1750.88	0.5254	0.6361
16.75	1764.73	1749.83	0.5167	0.6246
17.00	1763.92	1748.70	0.5081	0.6141
17.25	1763.09	1747.45	0.4998	0.6045
17.50	1762.23	1746.03	0.4915	0.5966
17.75	1761.34	1744.39	0.4835	0.5920
18.00	1760.42	1742.47	0.4756	0.5882
18.25	1759.49	1740.24	0.4678	0.5852
18.50	1758.53	1737.68	0.4602	0.5830
18.75	1757.55	1734.77	0.4527	0.5813
19.00	1756.54	1731.52	0.4454	0.5802
19.25	1755.52	1727.91	0.4381	0.5796
19.50	1754.48	1723.98	0.4311	0.5793
19.75	1753.41	1719.73	0.4241	0.5795
20.00	1752.33	1715.17	0.4172	0.5800

Table 5.40

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1772.46	1641.28	0.7241	1.1369
12.25	1772.55	1653.71	0.7102	1.0976
12.50	1772.56	1665.21	0.6969	1.0603
12.75	1772.51	1675.83	0.6839	1.0249
13.00	1772.39	1685.61	0.6713	0.9912
13.25	1772.21	1694.60	0.6590	0.9592
13.50	1771.98	1702.84	0.6471	0.9286
13.75	1771.68	1710.36	0.6355	0.8994
14.00	1771.34	1717.19	0.6243	0.8715
14.25	1770.94	1723.35	0.6133	0.8449
14.50	1770.50	1728.87	0.6026	0.8195
14.75	1770.01	1733.76	0.5921	0.7953
15.00	1769.48	1738.02	0.5819	0.7722
15.25	1768.91	1741.66	0.5720	0.7502
15.50	1768.30	1744.69	0.5622	0.7294
15.75	1767.65	1747.08	0.5527	0.7098
16.00	1766.97	1748.85	0.5434	0.6913
16.25	1766.26	1749.98	0.5343	0.6741
16.50	1765.51	1749.32	0.5254	0.6595
16.75	1764.73	1747.78	0.5167	0.6466
17.00	1763.92	1745.97	0.5081	0.6347
17.25	1763.09	1743.84	0.4998	0.6237
17.50	1762.23	1741.38	0.4915	0.6139
17.75	1761.34	1738.57	0.4835	0.6100
18.00	1760.42	1735.40	0.4756	0.6084
18.25	1759.49	1731.88	0.4678	0.6073
18.50	1758.53	1728.03	0.4602	0.6066
18.75	1757.55	1723.86	0.4527	0.6064
19.00	1756.54	1719.38	0.4454	0.6087
19.25	1755.52	1714.60	0.4381	0.6114
19.50	1754.48	1709.53	0.4311	0.6146
19.75	1753.41	1704.19	0.4241	0.6183
20.00	1752.33	1698.58	0.4172	0.6224

Table 5.41

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy = 800.0 kPa, Conf.Str.=320.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1772.46	1545.76	0.7241	1.3312
12.25	1772.55	1564.70	0.7102	1.2786
12.50	1772.56	1582.28	0.6969	1.2295
12.75	1772.51	1598.60	0.6839	1.1834
13.00	1772.39	1613.74	0.6713	1.1401
13.25	1772.21	1627.79	0.6590	1.0992
13.50	1771.98	1640.80	0.6471	1.0606
13.75	1771.68	1652.85	0.6355	1.0241
14.00	1771.34	1663.98	0.6243	0.9894
14.25	1770.94	1674.25	0.6133	0.9564
14.50	1770.50	1683.71	0.6026	0.9251
14.75	1770.01	1692.40	0.5921	0.8952
15.00	1769.48	1700.34	0.5819	0.8666
15.25	1768.91	1707.59	0.5720	0.8394
15.50	1768.30	1714.15	0.5622	0.8134
15.75	1767.65	1720.06	0.5527	0.7885
16.00	1766.97	1725.34	0.5434	0.7648
16.25	1766.26	1730.00	0.5343	0.7422
16.50	1765.51	1734.05	0.5254	0.7206
16.75	1764.73	1737.13	0.5167	0.7005
17.00	1763.92	1733.43	0.5081	0.6893
17.25	1763.09	1729.40	0.4998	0.6790
17.50	1762.23	1725.06	0.4915	0.6696
17.75	1761.34	1720.41	0.4835	0.6611
18.00	1760.42	1715.48	0.4756	0.6624
18.25	1759.49	1710.26	0.4678	0.6656
18.50	1758.53	1704.78	0.4602	0.6691
18.75	1757.55	1699.03	0.4527	0.6731
19.00	1756.54	1693.04	0.4454	0.6775
19.25	1755.52	1686.79	0.4381	0.6822
19.50	1754.48	1680.31	0.4311	0.6874
19.75	1753.41	1673.59	0.4241	0.6929
20.00	1752.33	1666.64	0.4172	0.6987

Table 5.42

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1841.16	1763.09	0.5666	0.8362
12.25	1838.20	1769.24	0.5729	0.8262
12.50	1835.25	1774.68	0.5792	0.8173
12.75	1832.32	1779.46	0.5854	0.8094
13.00	1829.41	1783.59	0.5916	0.8023
13.25	1826.51	1787.10	0.5978	0.7962
13.50	1823.62	1790.02	0.6039	0.7908
13.75	1820.74	1792.35	0.6100	0.7863
14.00	1817.88	1794.10	0.6161	0.7825
14.25	1815.02	1795.27	0.6222	0.7796
14.50	1812.18	1795.85	0.6283	0.7775
14.75	1809.34	1795.82	0.6344	0.7763
15.00	1806.51	1795.16	0.6405	0.7760
15.25	1803.69	1793.84	0.6466	0.7768
15.50	1800.88	1791.91	0.6527	0.7786
15.75	1798.08	1788.96	0.6588	0.7820
16.00	1795.28	1785.96	0.6649	0.7859
16.25	1792.49	1782.94	0.6711	0.7904
16.50	1789.70	1779.83	0.6773	0.7954
16.75	1786.92	1776.56	0.6834	0.8013
17.00	1784.15	1773.02	0.6896	0.8080
17.25	1781.38	1769.15	0.6959	0.8157
17.50	1778.61	1764.90	0.7021	0.8245
17.75	1775.85	1760.24	0.7084	0.8343
18.00	1773.10	1755.19	0.7147	0.8451
18.25	1770.35	1749.76	0.7211	0.8568
18.50	1767.60	1743.96	0.7275	0.8703
18.75	1764.85	1737.83	0.7339	0.8847
19.00	1762.11	1731.38	0.7404	0.8997
19.25	1759.37	1724.61	0.7469	0.9153
19.50	1756.64	1717.55	0.7534	0.9314
19.75	1753.90	1710.20	0.7600	0.9482
20.00	1751.17	1702.58	0.7666	0.9655

Table 5.43

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1841.16	1718.73	0.5666	0.9313
12.25	1838.20	1728.14	0.5729	0.9155
12.50	1835.25	1736.68	0.5792	0.9013
12.75	1832.32	1744.40	0.5854	0.8884
13.00	1829.41	1751.34	0.5916	0.8767
13.25	1826.51	1757.55	0.5978	0.8663
13.50	1823.62	1763.05	0.6039	0.8569
13.75	1820.74	1767.87	0.6100	0.8485
14.00	1817.88	1772.06	0.6161	0.8410
14.25	1815.02	1775.62	0.6222	0.8345
14.50	1812.18	1778.58	0.6283	0.8289
14.75	1809.34	1780.95	0.6344	0.8241
15.00	1806.51	1782.74	0.6405	0.8201
15.25	1803.69	1783.94	0.6466	0.8171
15.50	1800.88	1784.56	0.6527	0.8149
15.75	1798.08	1784.56	0.6588	0.8137
16.00	1795.28	1783.92	0.6649	0.8135
16.25	1792.49	1780.26	0.6711	0.8174
16.50	1789.70	1775.98	0.6773	0.8225
16.75	1786.92	1771.31	0.6834	0.8286
17.00	1784.15	1766.24	0.6896	0.8358
17.25	1781.38	1760.79	0.6959	0.8441
17.50	1778.61	1754.98	0.7021	0.8535
17.75	1775.85	1748.83	0.7084	0.8640
18.00	1773.10	1742.36	0.7147	0.8755
18.25	1770.35	1735.58	0.7211	0.8880
18.50	1767.60	1728.51	0.7275	0.9015
18.75	1764.85	1721.15	0.7339	0.9159
19.00	1762.11	1713.52	0.7404	0.9313
19.25	1759.37	1705.62	0.7469	0.9475
19.50	1756.64	1697.46	0.7534	0.9645
19.75	1753.90	1689.04	0.7600	0.9823
20.00	1751.17	1680.37	0.7666	1.0009

Table 5.44

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy =1200.0 kPa, Conf.Str.=480.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1841.16	1622.39	0.5666	1.1382
12.25	1838.20	1638.49	0.5729	1.1080
12.50	1835.25	1653.29	0.5792	1.0808
12.75	1832.32	1666.88	0.5854	1.0561
13.00	1829.41	1679.35	0.5916	1.0338
13.25	1826.51	1690.76	0.5978	1.0136
13.50	1823.62	1701.18	0.6039	0.9952
13.75	1820.74	1710.68	0.6100	0.9786
14.00	1817.88	1719.30	0.6161	0.9635
14.25	1815.02	1727.10	0.6222	0.9499
14.50	1812.18	1734.11	0.6283	0.9377
14.75	1809.34	1740.38	0.6344	0.9266
15.00	1806.51	1745.94	0.6405	0.9167
15.25	1803.69	1750.82	0.6466	0.9079
15.50	1800.88	1755.06	0.6527	0.9001
15.75	1798.08	1758.67	0.6588	0.8933
16.00	1795.28	1761.68	0.6649	0.8874
16.25	1792.49	1764.09	0.6711	0.8825
16.50	1789.70	1758.97	0.6773	0.8880
16.75	1786.92	1752.16	0.6834	0.8963
17.00	1784.15	1745.06	0.6896	0.9056
17.25	1781.38	1737.68	0.6959	0.9159
17.50	1778.61	1730.02	0.7021	0.9273
17.75	1775.85	1722.10	0.7084	0.9397
18.00	1773.10	1713.92	0.7147	0.9531
18.25	1770.35	1705.48	0.7211	0.9675
18.50	1767.60	1696.79	0.7275	0.9829
18.75	1764.85	1687.86	0.7339	0.9993
19.00	1762.11	1678.69	0.7404	1.0167
19.25	1759.37	1669.29	0.7469	1.0350
19.50	1756.64	1659.64	0.7534	1.0542
19.75	1753.90	1649.77	0.7600	1.0744
20.00	1751.17	1639.67	0.7666	1.0955

Table 5.45

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1893.13	1818.51	-0.1508	0.0255
12.25	1887.46	1822.02	-0.1436	0.0241
12.50	1881.89	1824.84	-0.1366	0.0230
12.75	1876.41	1827.00	-0.1298	0.0223
13.00	1871.01	1828.50	-0.1232	0.0219
13.25	1865.69	1829.34	-0.1167	0.0219
13.50	1860.44	1829.53	-0.1105	0.0223
13.75	1855.26	1829.04	-0.1043	0.0232
14.00	1850.14	1827.83	-0.0984	0.0244
14.25	1845.09	1825.89	-0.0925	0.0262
14.50	1840.09	1823.17	-0.0867	0.0285
14.75	1835.15	1819.71	-0.0811	0.0312
15.00	1830.26	1815.22	-0.0756	0.0355
15.25	1825.41	1810.14	-0.0701	0.0417
15.50	1820.62	1805.20	-0.0647	0.0484
15.75	1815.87	1800.39	-0.0594	0.0555
16.00	1811.16	1795.71	-0.0542	0.0631
16.25	1806.49	1791.10	-0.0490	0.0710
16.50	1801.86	1786.44	-0.0439	0.0794
16.75	1797.27	1781.76	-0.0389	0.0882
17.00	1792.71	1776.83	-0.0339	0.0973
17.25	1788.18	1771.58	-0.0289	0.1069
17.50	1783.68	1765.91	-0.0239	0.1169
17.75	1779.22	1759.77	-0.0190	0.1274
18.00	1774.78	1753.13	-0.0141	0.1382
18.25	1770.37	1746.01	-0.0093	0.1494
18.50	1765.99	1738.43	-0.0044	0.1610
18.75	1761.63	1730.44	0.0004	0.1729
19.00	1757.30	1722.04	0.0052	0.1851
19.25	1752.98	1713.29	0.0100	0.1976
19.50	1748.70	1704.19	0.0148	0.2105
19.75	1744.43	1694.76	0.0197	0.2236
20.00	1740.18	1685.03	0.0245	0.2370

Table 5.46

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1893.13	1773.35	-0.1508	0.0784
12.25	1887.46	1780.33	-0.1436	0.0736
12.50	1881.89	1786.47	-0.1366	0.0693
12.75	1876.41	1791.81	-0.1298	0.0655
13.00	1871.01	1796.39	-0.1232	0.0621
13.25	1865.69	1800.24	-0.1167	0.0592
13.50	1860.44	1803.39	-0.1105	0.0568
13.75	1855.26	1805.84	-0.1043	0.0547
14.00	1850.14	1807.63	-0.0984	0.0531
14.25	1845.09	1808.74	-0.0925	0.0520
14.50	1840.09	1809.18	-0.0867	0.0513
14.75	1835.15	1808.93	-0.0811	0.0511
15.00	1830.26	1807.95	-0.0756	0.0516
15.25	1825.41	1806.21	-0.0701	0.0584
15.50	1820.62	1803.70	-0.0647	0.0660
15.75	1815.87	1800.36	-0.0594	0.0743
16.00	1811.16	1795.29	-0.0542	0.0836
16.25	1806.49	1789.89	-0.0490	0.0933
16.50	1801.86	1784.09	-0.0439	0.1035
16.75	1797.27	1777.81	-0.0389	0.1140
17.00	1792.71	1771.05	-0.0339	0.1250
17.25	1788.18	1763.82	-0.0289	0.1364
17.50	1783.68	1756.13	-0.0239	0.1482
17.75	1779.22	1748.02	-0.0190	0.1603
18.00	1774.78	1739.53	-0.0141	0.1727
18.25	1770.37	1730.68	-0.0093	0.1854
18.50	1765.99	1721.48	-0.0044	0.1984
18.75	1761.63	1711.97	0.0004	0.2116
19.00	1757.30	1702.15	0.0052	0.2252
19.25	1752.98	1692.03	0.0100	0.2390
19.50	1748.70	1681.63	0.0148	0.2530
19.75	1744.43	1670.96	0.0197	0.2673
20.00	1740.18	1660.01	0.0245	0.2818

Table 5.47

Volume Change on Soaking - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=22.00, Energy =1600.0 kPa, Conf.Str.=160.0 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Volume Change (%)	Expected Max.Vol. Change (%)
12.00	1893.13	1674.47	-0.1508	0.1980
12.25	1887.46	1688.40	-0.1436	0.1855
12.50	1881.89	1701.07	-0.1366	0.1743
12.75	1876.41	1712.55	-0.1298	0.1640
13.00	1871.01	1722.93	-0.1232	0.1548
13.25	1865.69	1732.28	-0.1167	0.1463
13.50	1860.44	1740.66	-0.1105	0.1387
13.75	1855.26	1748.12	-0.1043	0.1317
14.00	1850.14	1754.72	-0.0984	0.1254
14.25	1845.09	1760.49	-0.0925	0.1197
14.50	1840.09	1765.47	-0.0867	0.1146
14.75	1835.15	1769.70	-0.0811	0.1101
15.00	1830.26	1773.20	-0.0756	0.1061
15.25	1825.41	1776.00	-0.0701	0.1115
15.50	1820.62	1778.11	-0.0647	0.1176
15.75	1815.87	1779.52	-0.0594	0.1245
16.00	1811.16	1780.25	-0.0542	0.1321
16.25	1806.49	1775.30	-0.0490	0.1428
16.50	1801.86	1766.61	-0.0439	0.1555
16.75	1797.27	1757.57	-0.0389	0.1684
17.00	1792.71	1748.20	-0.0339	0.1816
17.25	1788.18	1738.52	-0.0289	0.1951
17.50	1783.68	1728.54	-0.0239	0.2088
17.75	1779.22	1718.27	-0.0190	0.2228
18.00	1774.78	1707.72	-0.0141	0.2369
18.25	1770.37	1696.90	-0.0093	0.2513
18.50	1765.99	1685.82	-0.0044	0.2660
18.75	1761.63	1674.49	0.0004	0.2808
19.00	1757.30	1662.90	0.0052	0.2958
19.25	1752.98	1651.06	0.0100	0.3110
19.50	1748.70	1638.98	0.0148	0.3265
19.75	1744.43	1626.65	0.0197	0.3421
20.00	1740.18	1614.09	0.0245	0.3579

Table 5.48

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=17-26, Energy= 800.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	539.63	495.78
12.25	536.42	493.61
12.50	533.14	491.36
12.75	529.79	489.03
13.00	526.37	486.62
13.25	522.89	484.12
13.50	519.33	481.52
13.75	515.71	478.81
14.00	512.02	475.99
14.25	508.27	473.06
14.50	504.44	469.99
14.75	500.55	466.78
15.00	496.59	463.43
15.25	492.57	459.91
15.50	488.47	456.23
15.75	484.31	452.26
16.00	480.08	447.65
16.25	475.78	442.82
16.50	471.42	437.78
16.75	466.99	432.53
17.00	462.49	427.06
17.25	457.92	421.39
17.50	453.28	415.53
17.75	448.58	409.46
18.00	443.81	403.22
18.25	438.97	396.79
18.50	434.06	390.19
18.75	429.09	383.42
19.00	424.05	376.50
19.25	418.94	369.41
19.50	413.76	362.18
19.75	408.52	354.80
20.00	403.20	347.28

Table 5.49

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 800.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	539.63	491.60
12.25	536.42	489.43
12.50	533.14	487.19
12.75	529.79	484.89
13.00	526.37	482.52
13.25	522.89	480.08
13.50	519.33	477.56
13.75	515.71	474.96
14.00	512.02	472.28
14.25	508.27	469.50
14.50	504.44	466.63
14.75	500.55	463.65
15.00	496.59	460.56
15.25	492.57	457.36
15.50	488.47	454.02
15.75	484.31	449.85
16.00	480.08	444.66
16.25	475.78	439.26
16.50	471.42	433.66
16.75	466.99	427.87
17.00	462.49	421.90
17.25	457.92	415.74
17.50	453.28	409.41
17.75	448.58	402.92
18.00	443.81	396.26
18.25	438.97	389.45
18.50	434.06	382.48
18.75	429.09	375.37
19.00	424.05	368.12
19.25	418.94	360.73
19.50	413.76	353.21
19.75	408.52	345.55
20.00	403.20	337.77

Table 5.50

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=17-26, Energy= 800.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	539.63	485.60
12.25	536.42	483.35
12.50	533.14	481.05
12.75	529.79	478.69
13.00	526.37	476.28
13.25	522.89	473.82
13.50	519.33	471.30
13.75	515.71	468.72
14.00	512.02	466.08
14.25	508.27	463.37
14.50	504.44	460.59
14.75	500.55	457.74
15.00	496.59	454.82
15.25	492.57	451.81
15.50	488.47	447.88
15.75	484.31	442.13
16.00	480.08	436.21
16.25	475.78	430.12
16.50	471.42	423.87
16.75	466.99	417.46
17.00	462.49	410.91
17.25	457.92	404.20
17.50	453.28	397.36
17.75	448.58	390.37
18.00	443.81	383.26
18.25	438.97	376.01
18.50	434.06	368.63
18.75	429.09	361.12
19.00	424.05	353.49
19.25	418.94	345.74
19.50	413.76	337.87
19.75	408.52	329.88
20.00	403.20	321.77

Table 5.51

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	673.70	636.43
12.25	668.88	633.44
12.50	663.96	630.32
12.75	658.93	627.07
13.00	653.81	623.67
13.25	648.58	620.09
13.50	643.25	616.31
13.75	637.82	612.29
14.00	632.29	608.00
14.25	626.65	603.38
14.50	620.92	597.93
14.75	615.08	591.05
15.00	609.14	583.73
15.25	603.10	576.00
15.50	596.96	567.91
15.75	590.72	559.47
16.00	584.37	550.74
16.25	577.93	541.73
16.50	571.38	532.46
16.75	564.73	522.95
17.00	557.98	513.23
17.25	551.13	503.29
17.50	544.17	493.15
17.75	537.12	482.81
18.00	529.96	472.29
18.25	522.71	461.58
18.50	515.35	450.70
18.75	507.88	439.64
19.00	500.32	428.41
19.25	492.66	417.01
19.50	484.89	405.45
19.75	477.02	393.72
20.00	469.06	381.82

Table 5.52

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	673.70	629.12
12.25	668.88	626.11
12.50	663.96	623.01
12.75	658.93	619.82
13.00	653.81	616.53
13.25	648.58	613.14
13.50	643.25	609.62
13.75	637.82	605.96
14.00	632.29	602.15
14.25	626.65	598.17
14.50	620.92	591.86
14.75	615.08	583.84
15.00	609.14	575.51
15.25	603.10	566.90
15.50	596.96	558.04
15.75	590.72	548.94
16.00	584.37	539.62
16.25	577.93	530.09
16.50	571.38	520.35
16.75	564.73	510.42
17.00	557.98	500.31
17.25	551.13	490.01
17.50	544.17	479.53
17.75	537.12	468.88
18.00	529.96	458.06
18.25	522.71	447.06
18.50	515.35	435.90
18.75	507.88	424.58
19.00	500.32	413.09
19.25	492.66	401.44
19.50	484.89	389.62
19.75	477.02	377.65
20.00	469.06	365.52

Table 5.53

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	673.70	618.82
12.25	668.88	615.63
12.50	663.96	612.38
12.75	658.93	609.06
13.00	653.81	605.67
13.25	648.58	602.21
13.50	643.25	598.67
13.75	637.82	595.05
14.00	632.29	591.34
14.25	626.65	584.88
14.50	620.92	576.16
14.75	615.08	567.24
15.00	609.14	558.11
15.25	603.10	548.79
15.50	596.96	539.29
15.75	590.72	529.60
16.00	584.37	519.73
16.25	577.93	509.69
16.50	571.38	499.47
16.75	564.73	489.09
17.00	557.98	478.54
17.25	551.13	467.82
17.50	544.17	456.94
17.75	537.12	445.90
18.00	529.96	434.69
18.25	522.71	423.33
18.50	515.35	411.80
18.75	507.88	400.12
19.00	500.32	388.28
19.25	492.66	376.28
19.50	484.89	364.12
19.75	477.02	351.81
20.00	469.06	339.34

Table 5.54

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=17-26, Energy= 1600.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	780.86	737.18
12.25	774.43	732.60
12.50	767.87	727.76
12.75	761.17	722.64
13.00	754.33	717.21
13.25	747.36	711.42
13.50	740.26	705.23
13.75	733.02	697.41
14.00	725.64	688.77
14.25	718.13	679.63
14.50	710.48	670.01
14.75	702.70	659.94
15.00	694.78	649.45
15.25	686.73	638.57
15.50	678.54	627.33
15.75	670.21	615.74
16.00	661.76	603.84
16.25	653.16	591.63
16.50	644.43	579.12
16.75	635.57	566.34
17.00	626.56	553.30
17.25	617.43	539.99
17.50	608.16	526.43
17.75	598.75	512.63
18.00	589.21	498.58
18.25	579.53	484.30
18.50	569.72	469.79
18.75	559.77	455.05
19.00	549.69	440.09
19.25	539.47	424.90
19.50	529.11	409.49
19.75	518.62	393.86
20.00	508.00	378.02

Table 5.55

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 1600.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	780.86	729.16
12.25	774.43	724.79
12.50	767.87	720.27
12.75	761.17	715.56
13.00	754.33	710.65
13.25	747.36	705.53
13.50	740.26	699.78
13.75	733.02	690.26
14.00	725.64	680.31
14.25	718.13	669.97
14.50	710.48	659.27
14.75	702.70	648.23
15.00	694.78	636.86
15.25	686.73	625.19
15.50	678.54	613.23
15.75	670.21	600.99
16.00	661.76	588.49
16.25	653.16	575.72
16.50	644.43	562.70
16.75	635.57	549.44
17.00	626.56	535.94
17.25	617.43	522.20
17.50	608.16	508.23
17.75	598.75	494.04
18.00	589.21	479.61
18.25	579.53	464.97
18.50	569.72	450.10
18.75	559.77	435.01
19.00	549.69	419.71
19.25	539.47	404.19
19.50	529.11	388.45
19.75	518.62	372.50
20.00	508.00	356.34

Table 5.56

Pre-Stress - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=17-26, Energy= 1600.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Pre-Stress (kPa)	Expected Min Pre-Stress (kPa)
12.00	780.86	716.82
12.25	774.43	712.40
12.50	767.87	707.88
12.75	761.17	703.23
13.00	754.33	698.47
13.25	747.36	692.89
13.50	740.26	682.34
13.75	733.02	671.48
14.00	725.64	660.33
14.25	718.13	648.91
14.50	710.48	637.21
14.75	702.70	625.26
15.00	694.78	613.05
15.25	686.73	600.60
15.50	678.54	587.91
15.75	670.21	574.99
16.00	661.76	561.83
16.25	653.16	548.45
16.50	644.43	534.83
16.75	635.57	521.00
17.00	626.56	506.94
17.25	617.43	492.67
17.50	608.16	478.18
17.75	598.75	463.47
18.00	589.21	448.55
18.25	579.53	433.41
18.50	569.72	418.06
18.75	559.77	402.50
19.00	549.69	386.73
19.25	539.47	370.74
19.50	529.11	354.55
19.75	518.62	338.15
20.00	508.00	321.54

Table 5.57

Strength Intercept - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Intercept (kPa)	Expected Min.Str Intercept (kPa)
12.00	1841.16	1763.09	0.	0.
12.25	1838.20	1769.24	0.	0.
12.50	1835.25	1774.68	0.	0.
12.75	1832.32	1779.46	0.	0.
13.00	1829.41	1783.59	0.	0.
13.25	1826.51	1787.10	0.	0.
13.50	1823.62	1790.02	0.	0.
13.75	1820.74	1792.35	0.	0.
14.00	1817.88	1794.10	0.	0.
14.25	1815.02	1795.27	0.	0.
14.50	1812.18	1795.85	1.29	0.
14.75	1809.34	1795.82	3.51	0.
15.00	1806.51	1795.16	5.75	1.91
15.25	1803.69	1793.84	8.00	4.41
15.50	1800.88	1791.91	10.26	6.88
15.75	1798.08	1788.96	12.54	9.27
16.00	1795.28	1785.96	14.83	11.67
16.25	1792.49	1782.94	17.13	14.08
16.50	1789.70	1779.83	19.45	16.49
16.75	1786.92	1776.56	21.78	18.89
17.00	1784.15	1773.02	24.12	21.27
17.25	1781.38	1769.15	26.47	23.62
17.50	1778.61	1764.90	28.84	25.94
17.75	1775.85	1760.24	31.22	28.22
18.00	1773.10	1755.19	33.61	30.47
18.25	1770.35	1749.76	36.02	32.70
18.50	1767.60	1743.96	38.44	34.89
18.75	1764.85	1737.83	40.88	37.06
19.00	1762.11	1731.38	43.32	39.21
19.25	1759.37	1724.61	45.78	41.33
19.50	1756.64	1717.55	48.26	43.33
19.75	1753.90	1710.20	50.74	45.02
20.00	1751.17	1702.58	53.24	46.67

Table 5.58

Strength Intercept - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Intercept (kPa)	Expected Min.Str Intercept (kPa)
12.00	1841.16	1718.73	0.	0.
12.25	1838.20	1728.14	0.	0.
12.50	1835.25	1736.68	0.	0.
12.75	1832.32	1744.40	0.	0.
13.00	1829.41	1751.34	0.	0.
13.25	1826.51	1757.55	0.	0.
13.50	1823.62	1763.05	0.	0.
13.75	1820.74	1767.87	0.	0.
14.00	1817.88	1772.06	0.	0.
14.25	1815.02	1775.62	0.	0.
14.50	1812.18	1778.58	1.29	0.
14.75	1809.34	1780.95	3.51	0.
15.00	1806.51	1782.74	5.75	0.37
15.25	1803.69	1783.94	8.00	3.06
15.50	1800.88	1784.56	10.26	5.72
15.75	1798.08	1784.56	12.54	8.34
16.00	1795.28	1783.92	14.83	10.93
16.25	1792.49	1780.26	17.13	13.24
16.50	1789.70	1775.98	19.45	15.50
16.75	1786.92	1771.31	21.78	17.73
17.00	1784.15	1766.24	24.12	19.93
17.25	1781.38	1760.79	26.47	22.09
17.50	1778.61	1754.98	28.84	24.23
17.75	1775.85	1748.83	31.22	26.35
18.00	1773.10	1742.36	33.61	28.43
18.25	1770.35	1735.58	36.02	30.50
18.50	1767.60	1728.51	38.44	32.54
18.75	1764.85	1721.15	40.88	34.57
19.00	1762.11	1713.52	43.32	36.57
19.25	1759.37	1705.62	45.78	38.55
19.50	1756.64	1697.46	48.26	40.51
19.75	1753.90	1689.04	50.74	42.44
20.00	1751.17	1680.37	53.24	43.95

Table 5.59

Strength Intercept - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Intercept (kPa)	Expected Min.Str Intercept (kPa)
12.00	1841.16	1622.39	0.	0.
12.25	1838.20	1638.49	0.	0.
12.50	1835.25	1653.29	0.	0.
12.75	1832.32	1666.88	0.	0.
13.00	1829.41	1679.35	0.	0.
13.25	1826.51	1690.76	0.	0.
13.50	1823.62	1701.18	0.	0.
13.75	1820.74	1710.68	0.	0.
14.00	1817.88	1719.30	0.	0.
14.25	1815.02	1727.10	0.	0.
14.50	1812.18	1734.11	1.29	0.
14.75	1809.34	1740.38	3.51	0.
15.00	1806.51	1745.94	5.75	0.
15.25	1803.69	1750.82	8.00	0.
15.50	1800.88	1755.06	10.26	1.70
15.75	1798.08	1758.67	12.54	4.66
16.00	1795.28	1761.68	14.83	7.58
16.25	1792.49	1764.09	17.13	10.46
16.50	1789.70	1758.97	19.45	12.60
16.75	1786.92	1752.16	21.78	14.58
17.00	1784.15	1745.06	24.12	16.53
17.25	1781.38	1737.68	26.47	18.46
17.50	1778.61	1730.02	28.84	20.37
17.75	1775.85	1722.10	31.22	22.25
18.00	1773.10	1713.92	33.61	24.11
18.25	1770.35	1705.48	36.02	25.95
18.50	1767.60	1696.79	38.44	27.77
18.75	1764.85	1687.86	40.88	29.57
19.00	1762.11	1678.69	43.32	31.34
19.25	1759.37	1669.29	45.78	33.09
19.50	1756.64	1659.64	48.26	34.81
19.75	1753.90	1649.77	50.74	36.51
20.00	1751.17	1639.67	53.24	38.19

Table 5.60

Strength Angle - Medium Plastic Soils

$V_{(w)}$=0.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Angle (deg)	Expected Min.Str Angle (deg)
12.00	1841.16	1763.09	31.62	28.10
12.25	1838.20	1769.24	31.22	27.90
12.50	1835.25	1774.68	30.82	27.69
12.75	1832.32	1779.46	30.41	27.47
13.00	1829.41	1783.59	30.00	27.24
13.25	1826.51	1787.10	29.59	27.01
13.50	1823.62	1790.02	29.18	26.76
13.75	1820.74	1792.35	28.77	26.51
14.00	1817.88	1794.10	28.35	26.24
14.25	1815.02	1795.27	27.93	25.96
14.50	1812.18	1795.85	27.51	25.66
14.75	1809.34	1795.82	27.08	25.35
15.00	1806.51	1795.16	26.66	25.03
15.25	1803.69	1793.84	26.23	24.68
15.50	1800.88	1791.91	25.80	24.32
15.75	1798.08	1788.96	25.36	23.93
16.00	1795.28	1785.96	24.93	23.53
16.25	1792.49	1782.94	24.49	23.12
16.50	1789.70	1779.83	24.05	22.71
16.75	1786.92	1776.56	23.60	22.29
17.00	1784.15	1773.02	23.16	21.86
17.25	1781.38	1769.15	22.71	21.41
17.50	1778.61	1764.90	22.26	20.95
17.75	1775.85	1760.24	21.81	20.46
18.00	1773.10	1755.19	21.35	19.96
18.25	1770.35	1749.76	20.89	19.44
18.50	1767.60	1743.96	20.43	18.91
18.75	1764.85	1737.83	19.97	18.35
19.00	1762.11	1731.38	19.51	17.79
19.25	1759.37	1724.61	19.04	17.20
19.50	1756.64	1717.55	18.57	16.55
19.75	1753.90	1710.20	18.10	15.79
20.00	1751.17	1702.58	17.62	15.00

Table 5.61

Strength Angle - Medium Plastic Soils

$V_{(w)}$=1.5%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Angle (deg)	Expected Min.Str Angle (deg)
12.00	1841.16	1718.73	31.62	26.60
12.25	1838.20	1728.14	31.22	26.48
12.50	1835.25	1736.68	30.82	26.36
12.75	1832.32	1744.40	30.41	26.22
13.00	1829.41	1751.34	30.00	26.07
13.25	1826.51	1757.55	29.59	25.92
13.50	1823.62	1763.05	29.18	25.75
13.75	1820.74	1767.87	28.77	25.57
14.00	1817.88	1772.06	28.35	25.37
14.25	1815.02	1775.62	27.93	25.16
14.50	1812.18	1778.58	27.51	24.94
14.75	1809.34	1780.95	27.08	24.71
15.00	1806.51	1782.74	26.66	24.46
15.25	1803.69	1783.94	26.23	24.19
15.50	1800.88	1784.56	25.80	23.90
15.75	1798.08	1784.56	25.36	23.60
16.00	1795.28	1783.92	24.93	23.27
16.25	1792.49	1780.26	24.49	22.83
16.50	1789.70	1775.98	24.05	22.37
16.75	1786.92	1771.31	23.60	21.90
17.00	1784.15	1766.24	23.16	21.40
17.25	1781.38	1760.79	22.71	20.89
17.50	1778.61	1754.98	22.26	20.35
17.75	1775.85	1748.83	21.81	19.81
18.00	1773.10	1742.36	21.35	19.24
18.25	1770.35	1735.58	20.89	18.66
18.50	1767.60	1728.51	20.43	18.06
18.75	1764.85	1721.15	19.97	17.45
19.00	1762.11	1713.52	19.51	16.82
19.25	1759.37	1705.62	19.04	16.17
19.50	1756.64	1697.46	18.57	15.51
19.75	1753.90	1689.04	18.10	14.83
20.00	1751.17	1680.37	17.62	13.97

Table 5.62

Strength Angle - Medium Plastic Soils

$V_{(w)}$=3.0%, I_p=17-26, Energy= 1200.0 kPa, Conf.Str.=160-480 kPa

Water Content (%)	Expected Dry Density (Kg/cu.m)	Expected Min Dry Density (Kg/cu.m)	Expected Strength Angle (deg)	Expected Min.Str Angle (deg)
12.00	1841.16	1622.39	31.62	22.97
12.25	1838.20	1638.49	31.22	23.04
12.50	1835.25	1653.29	30.82	23.10
12.75	1832.32	1666.88	30.41	23.13
13.00	1829.41	1679.35	30.00	23.15
13.25	1826.51	1690.76	29.59	23.15
13.50	1823.62	1701.18	29.18	23.14
13.75	1820.74	1710.68	28.77	23.11
14.00	1817.88	1719.30	28.35	23.06
14.25	1815.02	1727.10	27.93	22.99
14.50	1812.18	1734.11	27.51	22.91
14.75	1809.34	1740.38	27.08	22.81
15.00	1806.51	1745.94	26.66	22.69
15.25	1803.69	1750.82	26.23	22.56
15.50	1800.88	1755.06	25.80	22.40
15.75	1798.08	1758.67	25.36	22.23
16.00	1795.28	1761.68	24.93	22.04
16.25	1792.49	1764.09	24.49	21.82
16.50	1789.70	1758.97	24.05	21.31
16.75	1786.92	1752.16	23.60	20.74
17.00	1784.15	1745.06	23.16	20.15
17.25	1781.38	1737.68	22.71	19.54
17.50	1778.61	1730.02	22.26	18.92
17.75	1775.85	1722.10	21.81	18.28
18.00	1773.10	1713.92	21.35	17.62
18.25	1770.35	1705.48	20.89	16.95
18.50	1767.60	1696.79	20.43	16.26
18.75	1764.85	1687.86	19.97	15.56
19.00	1762.11	1678.69	19.51	14.83
19.25	1759.37	1669.29	19.04	14.09
19.50	1756.64	1659.64	18.57	13.34
19.75	1753.90	1649.77	18.10	12.56
20.00	1751.17	1639.67	17.62	11.77

Section 6

PORE SIZE DISTRIBUTION

The engineering behaviour of compacted clay is said to be controlled largely by the soil fabric. Different compaction procedures produce differing fabrics. The relationships and charts produced in this report do not include any parameter to take into account the fabric of a soil mass. The inclusion of such a parameter could account for some of the apparent inconsistencies and gaps in the set of charts and relations. For instance two samples from different sites might show differing behaviour in spite of all characteristic parameters being the same. The difference arises due to varying fabric having been produced by different compaction equipment in use at the sites.

In the original proposal for this project it was stated that the magnitudes of behaviour parameters can be predicted using pore-size distributions (PSD).PSD appears to be a good quantitative indicator of the kind of fabric produced and is a potential numerical bridge between properties and compaction variables. Since then work performed at Purdue and elsewhere shows that the engineering behaviour of soil is controlled by not only the PSD but also by the fabric tensor (a directional quantity). The significance of fabric tensor on the engineering behaviour of soils renders the PSD a secondary parameter. Methods to characterize fabric tensor

are not yet available in a quantitative manner.

Using available data from White (1980), it appears, that various descriptors of soil fabric can be correlated to the water content of the lift and the compaction energy obtained by using different compactors. These are the basic variables that control the desired parameters (strength q_c, c', ϕ', etc.) in the Design Engineering option. As noted earlier the fabric produced, for a given set of compaction variables, is different for each type of compactor. Different compactors, thus, should have different correlations made for their resultant product. As only one compactor was found used by contractors on the work sampled by this study, the use of PSD did, indeed, become considered secondary.

It must, however, be indicated that, ultimately, the role of various compactors in creating soil fabric in the field must be clarified. This determination deserves consideration because it offers another step of improvement in the more effective and efficient use of compacted earth.

Section 7

SUMMARY AND CONCLUSIONS

A number of typical Indiana soils have been tested with the focus upon the compacted behaviour, in-service, in the field. The results were blended into those prepared from an earlier study. Charts and diagrams were prepared to assist the engineer: (1) where borrow is identified in advance of construction, to prepare the compaction specification to be assured that the earthwork, in-service, would exhibit a desired selected behaviour parameter magnitude; (2) where borrow is not identified prior to construction, to predict the behaviour parameter magnitudes that will be exhibited by the compacted earth, using inspection test results without other extensive testing. The procedures are guided by a "flow chart" in each case. A Computer program is provided for cases not precisely covered by the prepared tables.

The data base, and, thus, the charts and tables in this report, are limited to the soils and equipment in this and the predecessor projects. For these constraints, the procedures appear to offer, for the first time; (1) a methodical procedure which allows the engineer to select the behaviour parameter(s) desired for the project and to create the earthwork specification that will assure the presence of these parameters in the compacted product; (2) a procedure to predict the behaviour parameters of a product using only

inspection test results, without additional major testing. These are major strides in the improvement of the state-of-the-art of earthwork engineering.

The study indicated clearly that the range of water content in the lift is the most important characteristic of the earthwork to be compacted. The range of water content on the lift at time of compaction controls the variability of the behaviour parameters. Thus, to achieve the best possible parameters, with assurance, requires control of the allowable range of water content. This control must be part of the earthwork specification if best use is to be made of the innovative procedures from this study.

The data in these findings do not include an exhaustive coverage of Indiana soils, much less those from outside Indiana. The capabilities offered by the procedures of this study strongly urge that a continuing effort be made to keep adding new data to the data base. It is only in this way that more widespread effective earthwork will be performed.

Bibliography

1.) Altschaeffl,A.G., and Lovell,C.W., (1983) " Improving Embankment Design and Performance" FHWA/IN/JHRP-83/14.

2.) Essigman,M.S., (1978) " Examination of the Variability Resulting from Soil Compaction ", JHRP-76-28, Joint Highway Research Proj, Purdue Univ, IN.

3.) Garcia-Bengochia,I. (1978) " The Relation Between Permeability and Pore-Size Distribution of Compacted Clayey Silts" JHRP-78-4, Joint Highway Research Proj, Purdue Univ, IN.

4.) Lin,P.S., and Lovell,C.W., (1981) "Compressibility of Field Compacted Clay" FHWA/IN/JHRP-81/14, Joint Highway Research Proj, Purdue Univ, IN.

5.) Liang,Y., and Lovell,C.W., (1982) " Strength of Field Compacted Clayey Embankments" FHWA/IN/JHRP-82/1, Joint Highway Research Proj, Purdue Univ, IN.

6.) Nwaboukei,S.O., (1984) "Compressibility and Shear Strength Characteristics of Impact Compacted Lacustrine Clay", Ph.D thesis, Purdue univ, IN.

7.) Price,J.T., (1978) " Soil Compaction Specification Procedure for Desired Field Strength" JHRP-78-7, Joint Highway Research Proj, Purdue Univ, IN.

8.) Reed,M.A., (1977) "Frost Heaving Rate of Silty Soils as a function of Pore Size Distribution.", JHRP 77-15, Joint Highway Research Proj, Purdue Univ, IN.

9.) Scott,J.C., (1977) " Examination of the Variability of

Soaked Strength of Laboratory Compacted Clay", JHRP-77-8, Joint Highway Research Proj, Purdue Univ, IN.

10.) Seed,H.B., and Mitchell,J.B., and Chan,C.K., (1960) "The Strength of Compacted Cohesive soils" Research Conf. on Shear strength of Cohesive soils, ASCE, Boulder, pp877-964.

11.) Selig,E.T., (1971) "Unified system for Compactor Performance Specification " Paper No 710727, Soc. of Automotive Engineers, Sept. pp1-12.

APPENDICES

Appendix A

Effect of Variation in Water Content on the Stability of an Embankment Slope

Variation in water content in a compacted embankment results in a variation in strength. This section demonstrates the effect of such variation on the stability of compacted clay embankments.

Two cases have been considered, 1) a low embankment, 20 feet in height, and 2) a high embankment, 100 feet tall.

The embankments were assumed to be resting on a well compacted subgrade of strength such that the failure surface lies entirely within the built up embankment under consideration. A series of slope angles were considered and the minimum factor of safety, for slip surface failure, was noted for each case. The analysis was performed using the slope stability analysis program STABL available at Purdue University. The modified Bishop Method of Slices was used.

The parameters chosen were:

Water - Content, W_c = 18.75 %,

Plasticity Index, I_p = 22,

Compaction Stress, P_c = 800 kPa;

Variation in
Water Content, $V_{(w)}$ = 0.0, 1.5 & 4.0 %

This leads to the following

$V_{(w)}$	γ_d		γ_{moist}	
(%)	Kg/m^3	pcf	Kg/m^3	pcf
0.0	1760.4	109.68	2090.5	130.25
1.5	1735.4	108.12	2060.8	128.40
4.0	1696.9	105.73	2015.1	125.55

For the purpose of calculating the strength the embankments were divided into layers of equal thickness (two layers of ten feet each for the twenty feet embankment and five layers of twenty feet each for the hundred feet high embankment). The confining stress (σ_3), was calculated by assuming a stress ratio K $(=\frac{\sigma_3}{\sigma_1})$ as being equal to 0.4, and, then using $\sigma_3 = \sigma_v \times (\frac{1 + 2(0.4)}{3})$, where σ_v is the vertical stress, on a point at mid-height of a layer which approximates the average depth to failure surface d_{av}, due to overlying material. The strength (q_c), was calculated at the mid-height for each layer using the values of confining stress obtained as described above. These values are given in the following table (Table A.1).

Table A.1
Strength Values for Slope Stability Calculations

Layer No.	d_{av} (ft.)	σ_v (kPa)	σ_3 (kPa)	Strength q_c (kPa) $V_{(w)}$ (%) 0.0	1.5	4.0
Embankment height = 20 feet						
1	5.0	31.79	19.1	123.8	69.5	39.2
2	7.5	47.68	28.6	132.6	81.9	51.0
Embankment height = 100 feet						
1	10.0	63.58	38.2	140.1	92.4	60.8
2	30.0	190.73	114.4	180.8	144.5	110.5
3	50.0	317.89	190.7	208.8	173.7	140.3
4	60.0	381.46	228.9	220.7	184.0	151.7
5	40.0	254.32	152.6	195.7	160.9	126.8

STABL was run using the above data and the results obtained are tabulated in Table A.2.

Table A.2
Results of Slope Stability Analysis performed using Modified Bishop Method of Slices

Embankment Height (feet)	Embankment Slope (degrees)	Variation in W_c, $(V_{(w)})$ (%)	Factor of Safety Minimum	Factor of Safety % change from $V_{(w)}=1.5$
20	30	1.5	5.38	---
		4.0	3.35	-37.7
	45	1.5	3.96	---
		4.0	2.46	-37.9
	60	1.5	3.37	---
		4.0	2.08	-38.3
100	15	1.5	4.19	---
		4.0	3.38	-19.3
	20	1.5	3.15	---
		4.0	2.54	-19.4
	30	1.5	2.17	---
		4.0	1.75	-19.4

The preceding tabulation indicates that the effect of variation in water content is much the same (on a relative basis) independant of the embankment slope chosen This definitely indicates the need for closer control of spread in water content variability in embankment construction.

The next case to be studied is the situation when the embankment becomes saturated. For the purpose of this example it is assumed that the shorter embankment (20 feet high) gets saturated to the top and the higher **embankment** is saturated to a height of fifty feet from its base. Since this is a long term effect, hence effective stress parameters, ϕ', and c' are used in the analysis. From Table B.3 it is noted that these parameters are dependant solely on water content and compaction energy input, which have already been defined for the earlier, unsaturated case (page 141).

The value of ϕ' and c' are obtained, for the given conditions, using the program of Appendix D. These are tabulated in Table A.3 .

Table A.3
ϕ' and c' values for Slope Stability Calculations

$V_{(w)}$, % (%)	c' (kPa)	ϕ' (deg)
1.5	32.39	19.47
4.0	26.24	17.20

STABL was run using the above data and the results are presented as Table A.4.

Table A.4
Results of Slope Stability Analysis for Saturated Embankments performed using Modified Bishop Method of Slices

Embankment Height (feet)	Embankment Slope (degrees)	Variation in W_c, ($V_{(w)}$) (%)	Factor of Safety Minimum	Factor of Safety % change from $V_{(w)}$=1.5
20	20	1.5	3.87	---
		4.0	3.22	-16.8
	30	1.5	2.63	---
		4.0	2.19	-16.7
	45	1.5	1.87	---
		4.0	1.56	-16.6
100	15	1.5	1.97	---
		4.0	1.68	-14.7
	20	1.5	1.48	---
		4.0	1.26	-14.9
	25	1.5	1.18	---
		4.0	1.00	-15.3

STABL does not allow for direct control of the factor of safety, i.e., it is not possible to specify a factor of safety and then check for effect of variation in strength on the slope angle. But there is a simple, if somewhat approximate, procedure to do this. Plots of the Factor of Safety vs. Embankment slope can be drawn for various values of $V_{(w)}$,(Figure A.1 to Figure A.4). A line from the ordinate, at the required Factor of safety value, can be drawn parallel to the abscissa which would intersect the curves for different values of $V_{(w)}$. These points of intersection would give the slope angle at which the embankment could be built with the Factor of Safety, as required by the design, and, allowable variation in water

content as convenient for the construction procedures. These plots also serve as visual illustration of the effect of $V_{(w)}$% on slope stability for a given/required Factor of Safety and soil conditions.

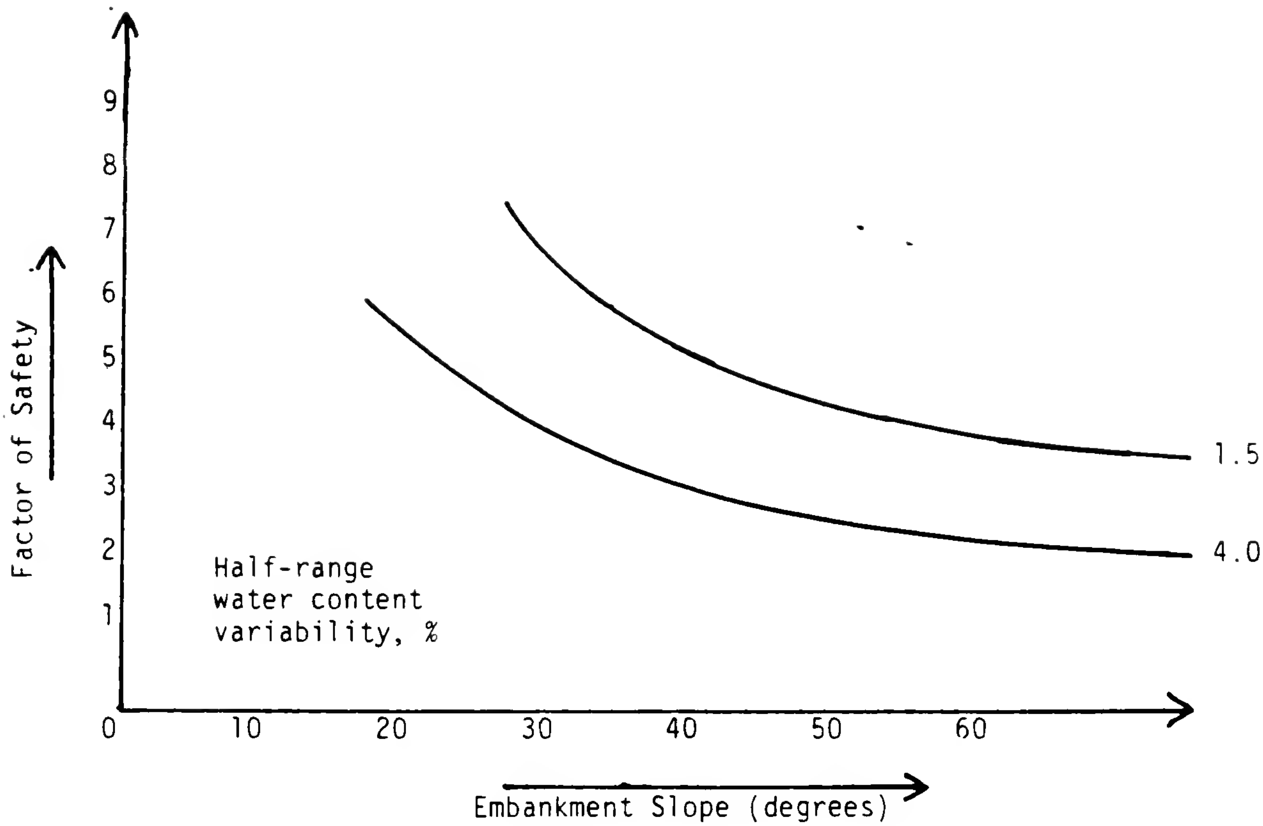

Figure A.1 Factor of Safety vs. Embankment Slope (Low)

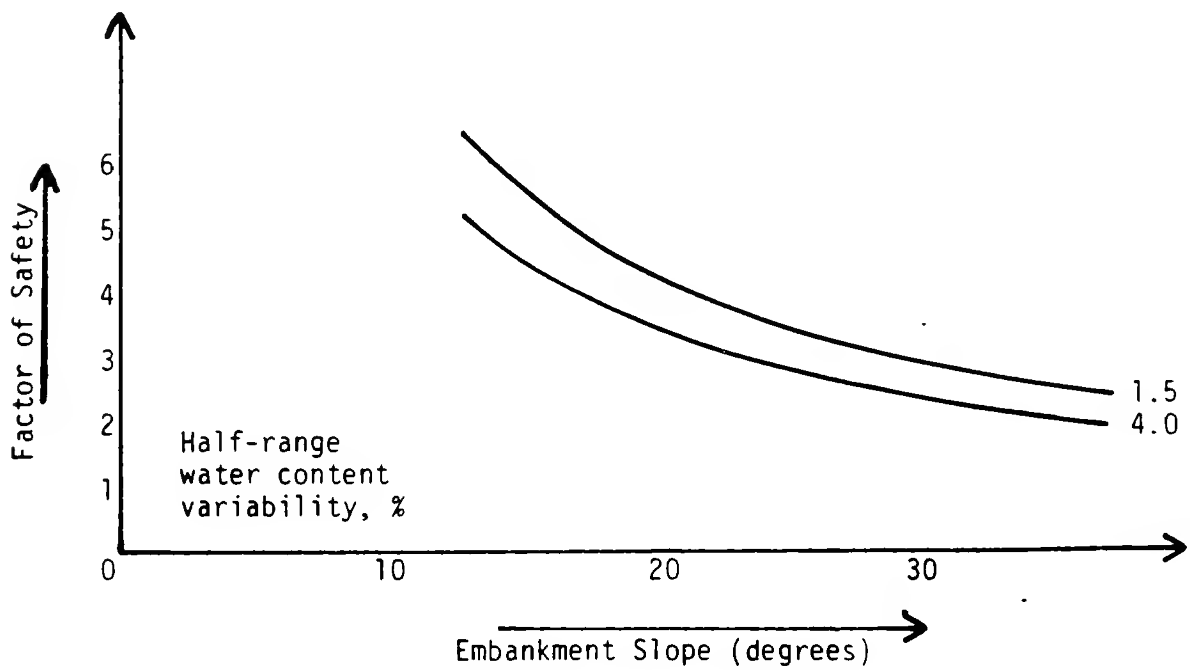

Figure A.2 Factor of Safety vs. Embankment Slope (High)

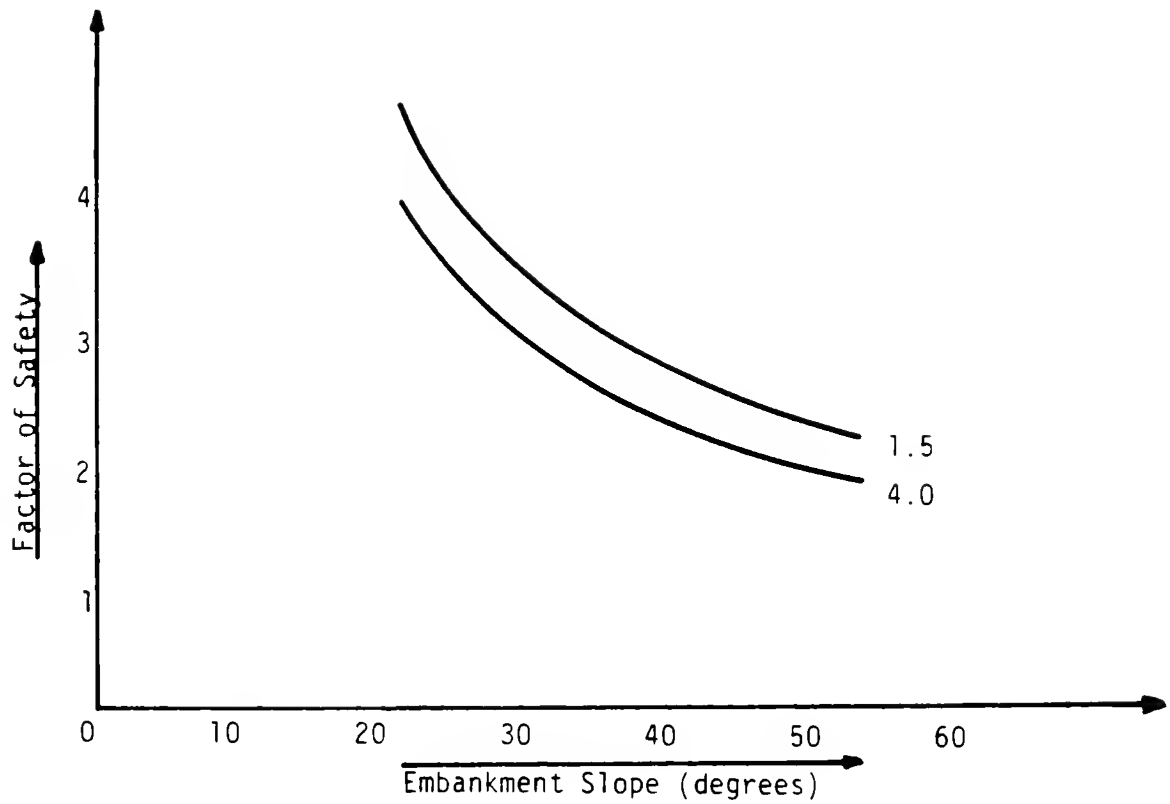

Figure A.3 Factor of Safety vs. Embankment Slope (Low)
(Saturated to Top)

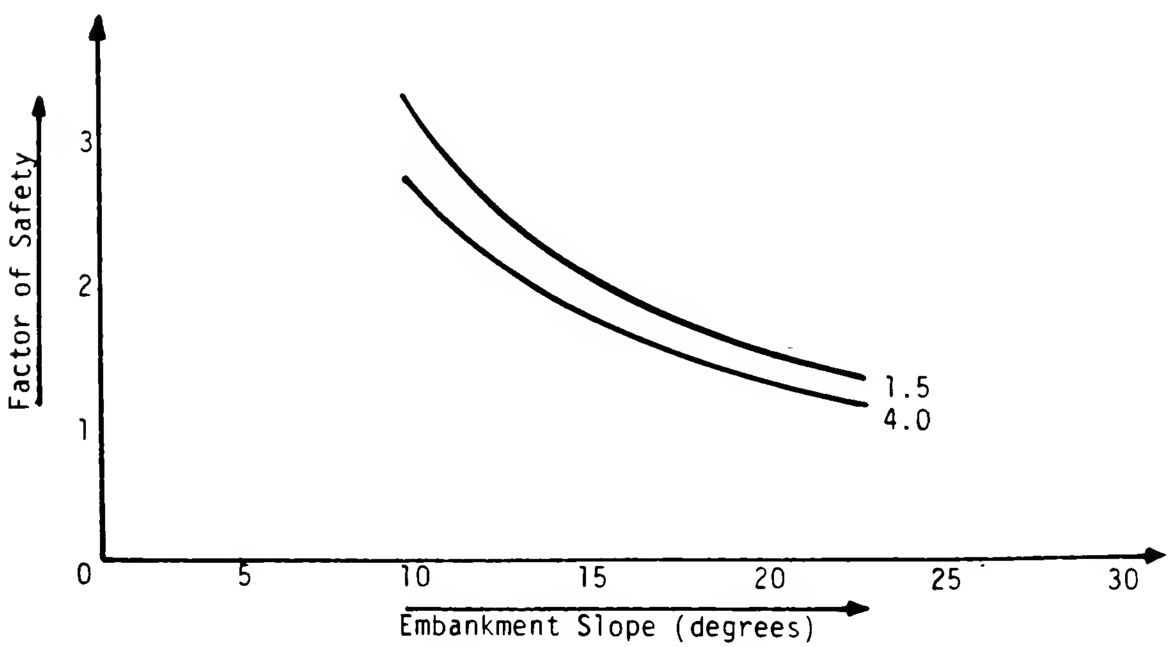

Figure A.4 Factor of Safety vs. Embankment Slope (High)
(Saturated to 50 feet height)

Table B.1

Soils and Rollers included in study

	Soil		Range in data base		
Compactor Type	Origin	Classification	I_p	w_c (%)	Compaction Pressure or Energy Input (kPa) (# of passes)
Cat 825	Avon(US 36) Danville to Avon	AASHTO (A-6 ?)	9.5 - 12.8	9 - 23	797(4) - 1020(6)
Cat 825	Evansville I-164	AASHTO (A - 4)	8.3 - 9.5	17 - 21	915(5) - 1204(8)
Cat 825	Fort Wayne (US 30)	AASHTO(A-7(6)?)	7.2 - 12.97	14 - 21	915(5) - 1020(6)
Cat 825	Valparaiso SR 49 bypass	AASHTO (A-2-4)	8.1 - 9.8	12 - 19	640(3) - 1204(8)
Raygo-Rascal 420 C	St. Croix SR 47 Relocation	AASHTO (A - 6) Unified (CL)	16.4 - 29.0	11 - 21	780(4) - 1525(16)
Cat 825	St. Croix SR 47 Relocation	AASHTO (A - 6) Unified (CL)	16.4 - 29.0	11 - 21	797(4) - 1771(16)

Caterpillar 825 is a Tamping Foot (or Sheepsfoot) roller
Raygo rascal 420C is a Vibratory Drum compactor

Table B.2

Regression results for Low Plastic Field Samples

DEPENDENT VARIABLE	REGRESSION MODEL	R^2	Overall F
Dry Density	$\bar{\gamma}_d = 2834.335 - 5513.866/W_c - 35.9433\ W_c \sqrt{I_p / 7.2}$	0.62	27.54
As-Compacted Strength	$\bar{q}_c = 181.98 - 0.634\ W_c^2 - 0.813\ \sigma_3 + 0.13625 \sqrt{\gamma_d\ W_c\ \sigma_3\ I_p / 7.2}$	0.51	4.78
1-D volume change (%), due to Soaking	$\left\lvert \frac{\Delta V}{V_o} \right\rvert (\%) = -0.946 + 2.818 \frac{\sqrt{P_o}}{\gamma_d} + 0.0242 \sqrt{P_o} + 0.0112\ W_c + 1.057 \sqrt{I_p / 20}$	0.45	3.7
As-Compacted Pre-Stress	$\bar{P}_s = 155.4 - 3.427 \sqrt{P_c} + 0.573\times10^{-4}\ W_c^2\ P_c - 2.61\ W_c \sqrt{I_p / 11}$	**0.81**	**46.13**
Soaked Pre-Stress	$\overline{SP}_s = 224.17 + 1.13\ P_o - 4.999 \sqrt{P_c} + 19.26\times10^{-5}\ W_c^2\ P_c - 4.824\ W_c \sqrt{I_p / 7.2}$	0.75	22.84

Compactor Type is Caterpillar 825 for all of the above

Table B.3

Regression results for Medium to High Plastic Field Samples

DEPENDENT VARIABLE	REGRESSION MODEL	R^2	Overall F
Dry Density	$\bar{\gamma}_d = 1935.29 - 6597.76/W_c - 8.076\times10^{-3} W_c P_c + 197.84 \frac{\sqrt{P_c}}{W_c} - 4.186\times10^{-4} \sqrt{P_c}\, W_c^2$	0.744	18.15
As-Compacted Strength	$\bar{q}_c = -956.04 - 0.531 W_c^2 \sqrt{I_p / 7.2} + 34.561 \sqrt{\gamma_d} - 66.985 \sqrt{I_p / 7.2} + 29.153\times10^{-3} \sqrt{\gamma_d W_c \sigma_3 I_p / 7.2}$	0.00	0.00
1-D volume change (%), due to Soaking	$\left\lvert\frac{\Delta V}{V_o}\right\rvert (\%) = -0.202 + 1022.78 \frac{\sqrt{P_o}}{\gamma_d} - 0.4989 \sqrt{P_o} - 0.0532 W_c + 0.1454 \sqrt{I_p / 20}$	0.838	42.65
As-Compacted Pre-Stress	$\bar{P}_s = -148.45 + 26.97 \sqrt{P_c} - 67.674\times10^{-5} W_c^2 P_c$	0.862	65.45

<u>Compactor Type is Caterpillar 825 or Raygo-Rascal 420C (Vibratory Drum) for all of the above. No distinction has been made in handling data</u>

Table B.3
(continued)

Regression results for Medium to High Plastic Field Samples

DEPENDENT VARIABLE	REGRESSION MODEL	R^2	Overall F
Effective Strength Intercept	$\overline{c}' = -102.79 + 42.459\ W_c - 0.826\ W_c \sqrt{\gamma_d}$	0.972	344.60
Effective Strength Angle	$\overline{\phi}' = 47.55 - 7.818\ W_c - 0.151\ W_c \sqrt{\gamma_d}$	0.893	83.23
Compactor Type is Caterpillar 825 or Raygo-Rascal 420C (Vibratory Drum) for all of the above. No distinction has been made in handling data			

Table C.1

Data for AVON Field Sample

W_c (%)	γ_d Kg/m^3	P_s kPa	P_o kPa	SP_s kPa	$\frac{\Delta V}{V_o}$ (%)	σ_3 kPa	q_c kPa	S_1 (%)	e_o	I_p	P_c kPa
16.70	1752	24.89	42.31	63.47	.118	---	---	85.71	.518	9.5	1020
17.27	1918	---	---	---	---	---	---	---	.387	11.0	797
23.62	1586	16.18	42.31	62.23	.380	---	---	92.81	.677	11.0	1020
10.74	1965	27.38	42.31	65.96	-0.013	---	---	80.70	.354	11.0	1020
7.09	2037	---	---	---	---	---	---	61.63	.306	11.0	1020
8.46	2037	---	---	---	---	---	---	73.54	.306	11.0	1020
9.37	1700	26.14	42.31	51.65	.369	---	---	43.65	.571	12.8	1020
13.12	1942	---	---	---	---	---	---	94.33	.370	11.0	1020
13.96	1942	19.91	42.31	53.51	.221	---	---	---	.370	11.0	1020
9.34	1680	24.89	42.31	77.16	.079	---	---	42.61	.583	12.8	1020
12.86	1918	18.67	9.96	42.31	-.011	---	---	88.40	.387	11.0	797
17.03	1875	---	---	---	---	---	---	---	.419	9.5	1020
13.48	2018	12.20	10.58	42.31	-.029	---	---	---	.318	9.5	1020
13.57	1693	---	---	---	---	---	---	63.21	.571	12.8	1020

Table C.2

Data for EVANSVILLE Field Sample

W_c (%)	γ_d Kg/m^3	P_s kPa	P_o kPa	SP_s kPa	$\frac{\Delta V}{V_o}$ (%)	σ_3 kPa	q_c kPa	S_i (%)	e_o	I_p	P_c kPa
16.91	1834	29.25	41.07	94.58	.190	138.0	211.0	90.55	.521	8.3	915
19.12	1746	19.91	27.38	43.56	.188	---	---	89.21	.598	8.3	1204
20.64	1731	29.87	59.74	101.43	.167	138.0	126.5	94.10	.612	8.3	915
17.59	1821	27.38	59.74	109.52	.169	138.0	233.3	92.25	.532	8.3	915
19.53	1775	---	---	---	---	69.0	101.0	95.26	.572	8.3	915
20.57	1635	29.25	60.98	124.45	.037	207.0	158.8	85.24	.706	9.5	915
19.08	1738	16.8	27.38	87.12	.211	276.0	241.5	88.00	.605	8.3	1204
20.49	1712	32.36	29.87	92.09	-.119	---	---	90.74	.630	8.3	915
19.02	1714	---	---	---	---	138.0	95.0	84.50	.628	8.3	915

Table C.3

Data for FORT-WAYNE Field Sample

W_c (%)	γ_d Kg/m^3	P_s kPa	P_o kPa	SP_s kPa	$\frac{\Delta V}{V_o}$ (%)	σ_3 kPa	q_c kPa	S_1 (%)	e_o	I_p	P_c kPa
20.70	1800	21.16	43.56	110.76	.289	138.0	65.5	---	.528	7.2	1020
15.94	1845	19.91	42.31	124.45	.286	69.0	163.3	89.37	.491	9.5	1020
17.81	1799	20.53	42.31	75.91	.217	276.0	151.0	92.66	.529	9.5	1020
18.48	1771	23.64	42.31	77.16	.082	207.0	119.0	91.93	.553	9.5	1020
14.80	1857	24.27	46.67	87.12	.267	138.0	283.3	84.60	.481	9.5	1020
18.65	1808	20.53	71.56	155.57	-0.086	207.0	239.5	98.44	.521	9.5	1020
18.08	1817	23.02	44.80	87.12	.189	276.0	272.0	96.83	.514	9.5	1020
16.66	1858	32.35	67.20	104.54	.397	69.0	338.8	95.43	.480	7.2	915
15.48	1682	---	---	---	---	138.0	216.5	67.15	.634	9.5	1020
16.59	1769	11.20	28.00	52.27	-.081	---	---	82.26	.555	13.0	1020
21.64	1719	18.05	28.00	58.49	-.181	207.0	217.5	99.18	.600	9.5	1020
16.36	1827	16.18	28.00	48.54	.167	276.0	205.0	89.05	.505	9.5	1020
20.00	1737	---	---	---	---	---	---	94.31	.583	9.5	1020
14.46	1871	20.53	40.45	74.67	.127	---	---	84.61	.470	9.5	1020
14.70	1886	21.78	40.45	72.18	.282	---	---	88.24	.458	9.5	1020
17.72	1885	22.40	40.45	69.70	.995	---	---	---	.459	9.5	1020

Table C.4

Data for VALPARAISO Field Sample

W_c (%)	γ_d Kg/m^3	P_s kPa	P_o kPa	SP_s kPa	$\frac{\Delta V}{V_o}$ (%)	σ_3 kPa	q_c kPa	S_i (%)	e_o	I_p	P_c kPa
12.38	1930	26.02	16.11	59.47	-0.109	---	---	96.62	.329	8.15	1020
18.85	1785	---	---	---	---	138.0	170.0	93.35	.563	8.15	1020
12.64	1792	26.02	21.06	42.12	0.039	---	---	63.81	.575	9.80	1020
14.45	1853	---	---	---	---	276.0	45.0	79.77	.505	8.15	1204
12.36	1952	44.61	16.11	56.38	-0.015	---	---	80.33	.429	8.15	640
12.65	1804	---	---	---	---	207.0	208.0	64.52	.547	8.15	1204
13.92	1890	19.20	10.53	29.74	-0.030	---	---	81.56	.476	8.15	1204
13.92	1890	19.20	21.06	59.47	0.012	---	---	81.56	.476	8.15	1204
12.10	1997	24.16	16.11	64.43	-0.014	---	---	84.95	.397	8.15	1020
13.39	1846	---	---	---	---	138.0	343.0	73.08	.511	8.15	1204
11.61	1908	28.50	10.53	46.46	-0.017	138.0	230.4	70.07	.462	8.15	1020
15.20	1788	32.84	10.53	44.0	0.009	69.0	78.6	76.23	.587	9.80	797
12.40	1771	---	---	---	---	---	---	60.13	.575	8.15	1204
13.76	1932	22.92	10.53	20.44	-0.005	---	---	86.45	.444	8.15	1204

Table C.5

Data for Medium Plastic Dry Density
(St. Croix Field Sample)
(From Liang & Lovell)

W_c (%)	γ_d Kg/m^3	P_c kPa
14.07	1740	780
15.48	1755.3	780
14.91	1754	780
17.36	1782.1	780
18.48	1756.7	780
15.27	1773.6	1038
14.77	1810.6	1038
14.31	1806.7	1038
17.03	1789	1038
18.12	1736.9	1038
14.18	1835.4	1525
14.07	1839.9	1525
15.40	1803.4	1525
16.38	1816.8	1525
19.18	1740.4	1525
14.54	1771.2	797
15.47	1762.5	797
14.68	1784.3	797
18.41	1745.1	797
17.57	1768.6	797
13.48	1860.1	1204
14.62	1847.3	1204
14.06	1773.7	1204
16.70	1795.2	1204
17.27	1782.9	1204
13.05	1877.4	1771
14.35	1824.7	1771
15.04	1815.5	1771
17.51	1783.8	1771
17.57	1791.3	1771

Table C.6

Data for Medium Plastic Strength
(St. Croix Field Sample)
(From Liang & Lovell)

σ_3 kPa	q_c kPa	W_c (%)	γ_d Kg/m^3	P_c kPa	e_o	S_i (%)	I_p
276.	804.3	15.58	1810.7	797	.540	80.5	21.0
276.	789.8	15.13	1816.8	797	.535	78.9	23.0
276.	235.6	20.22	1701.0	797	.640	88.2	22.0
276.	378.3	18.21	1761.6	797	.583	87.2	25.0
276.	746.5	14.15	1814.9	1204	.537	73.6	23.0
276.	959.3	12.05	1743.5	1204	.600	56.1	21.0
276.	449.6	17.	1803.	1204	.547	86.8	22.0
276.	478.3	18.75	1755.1	1204	.589	88.8	25.0
276.	685.9	15.	1843.7	1771	.513	81.6	23.0
276.	693.6	13.85	1907.3	1771	.462	83.6	21.0
276.	304.3	18.94	1741.4	1771	.602	87.9	22.0
276.	624.0	16.63	1808.5	1771	.542	85.6	25.0
276.	461.7	16.87	1628.9	780	.712	66.1	17.0
276.	465.8	15.9	1686.6	780	.654	67.9	17.0
276.	508.6	16.24	1824.9	780	.528	85.8	26.0
276.	416.1	18.85	1741.2	780	.602	87.4	25.0
276.	988.7	13.63	1783.8	1038	.563	67.5	17.0
276.	390.4	17.15	1795.3	1038	.553	86.5	26.0
276.	532.6	17.27	1738.2	1038	.604	79.7	25.0
276.	855.2	15.44	1831.	1525	.523	82.4	17.0
276.	504.9	14.7	1749.9	1525	.594	69.1	20.0
276.	382.0	17.85	1784.3	1525	.563	88.5	26.0
276.	211.3	20.25	1707.6	1525	.633	89.2	25.0
138.	536.3	15.4	1718.9	797	.622	69.08	21.0
138.	781.1	13.5	1819.4	797	.533	70.67	23.0
138.	539.4	15.52	1695.7	797	.645	67.13	21.0
138.	235.6	18.4	1753.1	797	.591	86.86	22.0
138.	264.7	18.55	1709.2	797	.632	81.89	25.0
138.	691.1	14.51	1738.3	1204	.604	67.02	23.0
138.	650.1	11.1	1808.2	1204	.542	57.14	21.0
138.	195.3	18.62	1745.4	1204	.598	86.87	22.0
138.	472.9	16.47	1742.5	1204	.6	76.59	25.0
138.	771.4	13.5	1787.8	1771	.56	67.26	23.0
138.	546.4	15.84	1680.	1771	.66	66.96	21.0
138.	278.3	19.	1729.9	1771	.614	86.34	22.0

Table C.6
(continued)

Data for Medium Plastic Strength
(St. Croix Field Sample)
(From Liang & Lovell)

σ_3 kPa	q_c kPa	W_c (%)	γ_d Kg/m^3	P_c kPa	e_o	S_i (%)	I_p
138.	390.7	16.38	1815.7	1771	.536	85.26	25.0
138.	562.9	13.33	1639.	780	.701	53.05	18.0
138.	545.7	15.53	1766.4	780	.579	74.83	17.0
138.	538.4	14.5	1711.7	780	.629	64.32	20.0
138.	312.8	18.3	1740.4	780	.602	84.8	26.0
138.	201.8	18.5	1769.1	780	.576	89.6	25.0
138.	721.1	13.46	1732.2	1038	.61	61.6	18.0
138.	610.1	15.5	1849.5	1038	.508	85.1	17.0
138.	309.7	16.67	1692.5	1038	.648	71.8	20.0
138.	334.2	15.11	1816.5	1038	.535	78.8	26.0
138.	186.8	19.8	1728.	1038	.614	90.	25.0
138.	597.5	16.48	1814.1	1525	.537	85.6	18.0
138.	736.	14.28	1803.4	1525	.546	73.	17.0
138.	311.3	17.13	1772.5	1525	.573	83.4	20.0
138.	502.5	14.86	1862.3	1525	.497	83.4	26.0
138.	214.4	16.25	1791.8	1525	.556	81.5	25.0
69.	859.3	12.5	1840.5	797	.515	67.7	21.0
69.	495.	16.12	1792.5	797	.556	80.9	23.0
69.	496.2	14.25	1768.	797	.577	68.9	21.0
69.	143.2	20.52	1706.	797	.635	90.2	22.0
69.	412.3	17.	1800.5	797	.549	86.4	25.0
69.	611.3	12.	1746.5	1204	.597	56.1	21.0
69.	503.8	14.85	1824.2	1204	.529	78.4	23.0
69.	330.3	18.16	1744.9	1204	.598	84.7	21.0
69.	678.4	14.64	1876.2	1204	.486	84.	22.0
69.	233.6	17.51	1794.4	1204	.554	88.2	25.0
69.	685.7	13.	1852.2	1771	.506	71.68	21.0
69.	657.2	14.68	1835.1	1771	.52	78.81	23.0
69.	677.2	17.54	1741.2	1771	.602	81.34	23.0
69.	809.4	13.63	1884.9	1771	.48	79.22	21.0
69.	281.9	15.77	1842.1	1771	.514	85.6	22.0
69.	240.3	17.55	1790.2	1771	.558	87.75	25.0
69.	426.6	12.66	1709.8	780	.631	55.98	18.0
69.	381.6	15.00	1765.2	780	.58	72.16	17.0
69.	295.9	14.69	1752.4	780	.59	69.47	20.0

Table C.6
(continued)

Data for Medium Plastic Strength
(St. Croix Field Sample)
(From Liang & Lovell)

σ_3 kPa	q_c kPa	W_c (%)	γ_d Kg/m^3	P_c kPa	e_o	S_i (%)	I_p
69.	293.9	18.27	1773.7	780	.572	89.11	26.0
69.	404.0	13.56	1846.6	780	.51	74.18	25.0
69.	434.4	14.74	1750.8	1038	.583	70.54	18.0
69.	716.2	14.09	1842.9	1038	.513	76.63	17.0
69.	391.1	15.37	1724.2	1038	.617	69.9	20.0
69.	427.0	17.00	1807.4	1038	.543	87.34	26.0
69.	326.4	17.12	1779.8	1038	.567	84.24	25.0
69.	607.1	15.15	1834.3	1038	.52	81.29	18.0
69.	690.6	14.2	1839.4	1525	.516	76.78	17.0
69.	480.7	12.22	1790.1	1525	.558	61.1	20.0
69.	376.1	17.0	1842.1	1525	.514	92.28	26.0
69.	297.3	18.5	1785.3	1525	.562	91.84	25.0

Table C.7

Data for Medium Plastic Volume Change on Soaking
(St. Croix Field Sample)
(From Lin & Lovell)

I_p	$\frac{\Delta V}{V_o}$ (%)	W_c (%)	γ_d Kg/m^3	P_c kPa	S_i (%)	e_o	P_o kPa
21	-.39	13.00	1918.9	797	79.26	.459	161
23	-.04	13.25	1857.3	797	73.09	.508	161
25	-.10	16.60	1808.2	797	84.76	.549	161
22	.14	17.04	1750.9	1204	76.46	.599	161
21	.28	11.22	1745.9	1771	52.05	.604	161
22	.11	17.82	1782.0	1771	87.32	.571	161
20	.17	13.89	1776.4	780	67.50	.576	161
17	-.22	13.27	1845.4	1038	71.85	.517	161
26	-.26	16.94	1796.6	1038	85.00	.558	161
17	-.1	14.26	1795.6	1525	71.36	.559	161
21	.77	14.43	1785.8	797	71.14	.568	322
22	.79	20.35	1704.8	797	88.72	.642	322
23	.27	16.51	1833.6	1204	87.7	.527	322
21	.60	19.08	1718.1	1204	84.82	.63	322
22	.19	15.33	1863.4	1204	85.43	.503	322
23	.01	14.26	1858.6	1771	78.81	.507	322
22	.46	16.78	1797.3	1771	84.2	.558	322
20	.33	13.69	1852.1	780	74.90	.512	322
26	.56	20.07	1739.1	780	90.58	.610	322
17	.14	14.37	1864.8	1038	80.25	.502	322
20	.14	14.11	1911.6	1038	84.99	.465	322
17	.12	13.17	1894.4	1525	77.14	.478	322
23	.29	13.51	1869.2	797	75.98	.498	483
22	.39	16.28	1822.0	797	84.86	.537	483
23	.26	16.47	1836.3	1204	87.85	.525	483
21	.65	18.09	1773.0	1204	87.46	.579	483
22	.45	16.90	1802.5	1204	85.50	.553	483
23	1.55	14.1	1719.4	1771	63.04	.629	483
22	.12	14.76	1867.4	1771	82.82	.499	483
17	.26	15.71	1824.7	780	82.32	.534	483
20	.28	15.20	1836.2	780	81.06	.525	483
26	.21	15.05	1866.9	780	84.31	.500	483
17	.16	14.99	1856.9	1038	82.61	.508	483
20	.25	15.54	1859.5	1038	85.99	.506	483
26	.51	17.15	1809.1	1038	87.60	.548	483
17	.23	14.91	1885.1	1525	86.07	.485	483

Table C.8

Data for Medium Plastic Pre Stress
(St. Croix Field Sample)
(From Lin & Lovell)

P_s kPa	W_c (%)	γ_d Kg/m^3	P_c kPa	I_p	S_i (%)	e_o
530	12.64	1654.6	797	21.0	51.12	.692
440	18.37	1618.8	797	23.3	70.49	.730
520	13.23	1645.2	797	21.1	52.78	.702
450	17.36	1723.3	797	23.3	77.80	.625
400	17.26	1707.1	797	24.8	75.48	.640
750	12.47	1799.1	1204	21.0	62.78	.556
640	12.63	1855.3	1204	21.1	69.45	.509
610	17.27	1738.3	1204	22.3	79.17	.611
610	16.44	1804.0	1204	24.8	83.37	.552
800	10.65	1910.0	1771	21.0	63.98	.466
750	11.96	1892.4	1771	23.3	69.80	.480
615	15.79	1804.1	1771	22.3	80.09	.552
740	12.98	1837.9	1771	24.8	69.42	.523
510	12.61	1795.0	780	18.1	63.04	.560
500	12.59	1819.7	780	16.9	65.42	.604
490	14.06	1827.7	780	26.5	73.98	.532
500	15.60	1779.5	1038	24.8	76.16	.573
530	13.66	1888.2	1038	18.1	79.19	.483
580	14.03	1824.3	1038	20.4	73.46	.535
520	17.17	1821.2	1038	26.5	89.47	.537
560	15.89	1808.3	1038	24.8	81.11	.548
820	12.61	1856.0	1525	24.8	69.44	.509
800	13.16	1817.4	1525	18.1	68.13	.541
820	12.18	1847.3	1525	20.4	66.11	.516

Table C.9

Data for Medium Plastic ϕ' and c'
(St. Croix Field Sample)
(From Liang & Lovell)

I_p	ϕ' (deg)	c' kPa	W_c (%)	γ_d Kg/m^3
18	27.8	0.0	12.0	1733.0
17	26.4	6.7	14.0	1753.0
20	24.5	18.7	16.0	1761.9
26	21.3	35.4	18.0	1762.2
25	16.1	57.3	20.0	1756.0
17	27.8	2.3	14.0	1794.9
20	25.1	16.6	16.0	1784.7
26	21.3	32.2	18.0	1767.6
25	21.3	61.2	20.0	1744.7
20	25.1	14.4	16.0	1807.3
26	21.3	35.4	18.0	1763.3
25	14.4	62.0	20.0	1716.4
23	27.1	2.8	14.0	1786.0
21	24.5	16.5	16.0	1762.0
22	20.7	36.4	18.0	1754.0
25	16.7	55.3	20.0	1756.0
23	26.4	5.6	14.0	1827.0
21	24.5	13.7	16.0	1780.0
22	22.0	32.3	18.0	1778.0
25	15.5	57.1	20.0	1760.0
21	24.5	16.5	16.0	1796.0
22	21.3	34.4	18.0	1778.0
25	15.5	57.1	20.0	1762.0

Help Manual for "Quality Assurance" Computer Program

The program is generalized so that it handles both low plastic and medium plastic soils. It produces tables similar to those included in this report as Table 5-1 to 5-62.

The program works in SI units as well as customary US units. Care must be taken that the data file is consistent in the units used.That is to say only one kind of units must be used in the data file. The user is queried as to the units being used at the beginning of program execution.

The program can produce any number of tables for all sets of properties, in any desired order, at one run. The tables will be produced in the same sequence as the data is input and each will be labelled properly to avoid confusion in sorting them for use.

The range of water content for which each relationship is valid is built into the program, only the water content step desired need be specified.

All the data should be contained in one file . The user is queried for the name of the data file when the program begins executing and the name is accepted from the standard input (keyboard in this case).

All user responses must be enclosed within single quotes.

Each table is stored in a seperate file so the user will be asked for a new filename as many times as there are tables required.

The following explains the order in which data must be stored in the data file:

Line 1	N1 --	Positive integer which specifies the Engineering Property for which a table is desired,(see Table D.1),
	R1 --	Plasticity Index, I_p;
Line 2	R2 --	Energy Level (P_c), in kPa or psi,
	R3 --	Confining Stress (σ_3 or P_0) in kPa or psi,
	R4 --	Step in Water Content,
	R5 --	Half-range in Water Content Variability, %

Line 1 and Line 2 must be repeated, with appropriate values, for each table when more than one table is required at one run of the program.

The last line must have the following format:

Line (2n+1)	N --	Any negative integer, this causes the program to stop,
	R --	Any arbitrary real number.

The total number of lines in the data file must be an odd number, and the last line should begin with a negative integer. This fact can be used as a quick check for the validity of the data file.

Table D.1

N1 values for computer-program data-file

Engineering Property		N1 value
For Low Plastic soils		
Dry Density	γ_d	1
Strength	q_c	2
1-D Volume Change on Soaking	$\frac{\Delta V}{V_o}$	3
Pre Stress	P_s	4
Soaked Pre-Stress	SP_s	5
For Medium Plastic Soils		
Dry Density	γ_d	6
Strength	q_c	7
1-D Volume Change on Soaking	$\frac{\Delta V}{V_o}$	8
Pre Stress	P_s	9
Effective Stress Strength Intercept	c'	10
Effective Stress Strength Angle	ϕ'	11

```
        real xxd(10,10),xxs(10,10),coed(10),coes(10),inc
        character *60 title
        character *20 name1,name2,snunit
        character *10 st1,st2,st3,st4,st5,st6
c
        write(6,*) 'Please give data file name'
        write(6,*)
        read(5,*) name1
        open(unit=10,file=name1,status='old',form='formatted')
c
        write(6,*) 'What system of units are you using ?'
        write(6,*) 'Type in  ''U''  if U.S. Customary   or'
        write(6,*) 'type in  ''S''  if SI.'
        write(6,*)
        read(5,*) snunit
c
        if ((snunit .eq. 'U') .or. (snunit .eq. 'u')) then
          sm1=6.895
          sm2=16.052
          st1='  (pcf)  '
          st2='(psi)'
          st3='psi'
          st4='87 - 174'
          st5=' 10-40'
          st6='23-69.5'
        else if ((snunit .eq. 'S') .or. (snunit .eq. 's')) then
          sm1=1.0
          sm2=1.0
          st1='(kg/cu.m)'
          st2='(kpa)'
          st3='kpa'
          st4='600-1200'
          st5='69-276'
          st6='160-480'
        endif

c
1111    read(10,*) nnn,pi
        if (nnn .lt. 0) go to 1000
c
        write(6,*) 'Please give output file name'
        write(6,*)
        read(5,*) name2
c
        open(unit=11,file=name2,status='new',form='formatted')


        if ((pi .ge. 7.0) .and. (pi .le. 13.0)) then
            go to 199
```

```
        else if ((pi .ge. 16.0) .and. (pi .le. 29.0)) then
            go to 299
        else
           go to 101
        endif
c   Low Plastic routing
199     go to (111,112,113,114,115,101,101,101,101,101,101) nnn
c   High Plastic routing
299     go to (101,101,101,101,101,211,212,213,214,215,216) nnn
101     write(6,*) 'There is an erroneous N value in the data file'
        write(6,*) 'EXECUTION TERMINATED'
        go to 1000
c ************************************************************************
c Section for Low Plastic Density prediction tables
c ************************************************************************
111     read(10,*) pc,cp,inc,wv
        pc=pc*sml
        cp=cp*sml
        title='Dry Density - Low Plastic Soils'
c
        write(11,180) title
180     format(//////26x,a50)
c
        write(11,1801) wv,pi,st4,st3,st5,st3
1801    format(/13x,'V(w)=',f3.1,' %, PI=',f4.1,', Energy=',
     $a8,a3,', conf.Str.=',a6,a3)
c
        write(11,1001) stl,stl
1001    format(20x,'____________________________________________',
     $//36x,'Expected',4x,'Expected',
     $/26x,'Water',5x,'Dry',9x,'Min Dry',
     $/25x,'Content',4x,'Density',5x,'Density',
     $/27x,'(%)',5x,a9,3x,a9,
     $/20x,'____________________________________________',/)
c
        wc=9.75
        ninc=12.25/inc
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
c
        do 2001 ll = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        wc = wc + inc
c
        densw=dens/sm2
        denminw=denmin/sm2
c
```

```
      write(11,1901) wc,densw,denminw
 2001 continue
 1901 format(19x,3f12.2)
      go to 1999
c
c *************************************************************************
c Section for Low Plastic Strength prediction tables
c *************************************************************************
c
112   read(10,*) pc,cp,inc,wv
      pc=pc*sml
      cp=cp*sml
c
      title='Strength - Low Plastic Soils'
c
      write(11,180) title
c
      cpw=cp/sml
      write(11,1802) wv,pi,st4,st3,cpw,st3
 1802 format(/12x,'V(w)=',f3.1,'%, PI=',f4.1,', Energy=',
     $a8,a3,', Conf.Str.=',f5.1,a3)
c
      write(11,1002) stl,stl,st2,st2
1002  format(10x,'___________________________________________________',
     $'____________________',//24x,'Expected',4x,'Expected',4x,'Expected'
     $,4x,'Expected',/14x,'Water',5x,'Dry',9x,'Min Dry',5x,'Strength'
     $,4x,'Minimum',/13x,'Content',4x,'Density',5x,'Density',17x,
     $'Strength',/15x,'(%)',5x,a9,3x,a9,5x,a5,
     $7x,a5,/10x,'___________________________________________________',
     $'____________________',/)
c
c
      wc=9.75
      ninc=10.25/inc
c
      nchk=1
      call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
      nchk=2
      call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
c
      do 2002 ll = 1,ninc
      scs=0.0
      call density (xxd,sd,nd,wc,dens,denmin,coed,alsmd,pc,vd,
     1 wv,pi,scs,nnn)
      call strnth (xxs,ss,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
     1 wv,pi,nnn)
      wc = wc + inc
```

```
        densw=dens/sm2
        denminw=denmin/sm2
        qcw=qc/sm1
        qcminw=qcmin/sm1
c
        write(11,1902) wc,densw,denminw,qcw,qcminw
 2002   continue
 1902   format(7x,5f12.2)
        go to 1999
c
c ************************************************************************
c Section for Low Plastic, Volume change on Soaking prediction tables
c ************************************************************************
c
113     read(10,*) pc,cp,inc,wv
        pc=pc*sm1
        cp=cp*sm1
        title='Volume Change on Soaking - Low
     $ Plastic Soils'
c
        write(11,180) title
        cpw=cp/sm1
        write(11,1802) wv,pi,st4,st3,cpw,st3
c
        wc=11.75
        ninc=8.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
        nchk=2
        call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
c
        write(11,1003) st1,st1
1003    format(10x,'_____________________________________________',
     $'_________________',//24x,'Expected',4x,'Expected',4x,'Expected'
     $,4x,'Expected',/14x,'Water',5x,'Dry',9x,'Min Dry',5x,'Volume',
     $6x,'Max.Vol.',/13x,'Content',4x,'Density',5x,'Density',5x,
     $'Change',6x,'Change',/15x,'(%)',5x,a9,3x,a9,
     $6x,'(%)',9x,'(%)',/10x,'____________________________________________',
     $'_____________________________',/)
c
        do 2003 ll = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        call strnth (xxs,ss,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
     1  wv,pi,nnn)
        wc = wc + inc
```

```
        densw=dens/sm2
        denminw=denmin/sm2
c
        write(11,1903) wc,densw,denminw,qc,qcmin
 2003   continue
 1903   format(7x,3f12.2,2f12.4)
        go to 1999
c
c ********************************************************************
c Section for Low Plastic Prestress prediction tables
c ********************************************************************
c
114     read(10,*) pc,cp,inc,wv
        pc=pc*sm1
        cp=cp*sm1
        title='Pre-Stress - Low Plastic Soils'
c
        write(11,180) title
        pcw=pc/sm1
        write(11,1804) wv,pi,pcw,st3,st5,st3
1804    format(/15x,'V(w) = ',f3.1,'%, PI=',f4.1,', Energy=',
     $f6.1,a4,', Conf.Str.= ',a6,a4)
c
        wc=9.25
        ninc=12.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
c
        write(11,1004) st2,st2
1004    format(20x,'_______________________________________________',
     $//36x,'Expected',5x,'Expected',
     $/26x,'Water',7x,'Pre-',7x,'Min Pre-',
     $/25x,'Content',5x,'Stress ',6x,'Stress ',
     $/27x,'(%)',8x,a5,7x,a5,
     $/20x,'_______________________________________________',/)
c
        do 2004 ll = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        wc = wc + inc
c
        densw=dens/sm1
        denminw=denmin/sm1
c
        write(11,1904) wc,densw,denminw
 2004   continue
 1904   format(19x,3f12.2)
        go to 1999
```

```
c
c ************************************************************************
c Section for Low Plastic Soaked Pre Stress prediction tables
c ************************************************************************
c
115     read(10,*) pc,cp,inc,wv
        pc=pc*sml
        cp=cp*sml
        title='Soaked Pre-Stress - Low Plastic
     $ Soils'
c
        write(11,180) title
        pcw=pc/sml
        cpw=cp/sml
        write(11,1805) wv,pi,pcw,st3,cpw,st3
 1805   format(/19x,'V(w)=',f3.1,'%, PI=',f4.1,', Energy=',
     $f6.1,a3,',Conf.Str.=',f6.1,a3)
c
        wc=9.75
        ninc=12.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
c
        write(11,1005) st2,st2
1005    format(12x,'______________________________________________________',
     $'___________',//39x,'Expected',10x,'Expected',
     $/24x,'Water',11x,'Soaked',10x,'Min Soaked',
     $/23x,'Content',8x,'Pre-Stress',8x,'Pre-Stress',
     $/25x,'(%)',12x,a5,13x,a5,
     $/12x,'______________________________________________________',
     $'___________',/)
c
        scs=cp
        do 2005 ii = 1,ninc
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        wc = wc + inc
        densw=dens/sml
        denminw=denmin/sml
        write(11,1905) wc,densw,denminw
 2005   continue
 1905   format(13x,3f17.2)
        go to 1999
```

```
c ***********************************************************************
c Section for Medium Plastic Density prediction tables
c ***********************************************************************
211     read(10,*) pc,cp,inc,wv
        pc=pc*sml
        cp=cp*sml
.       title='Dry Density - Medium Plastic Soils'
c
        write(11,180) title
        pcw=pc/sml
        write(11,1811) wv,pcw,st3,st6,st3
 1811   format(/12x,'V(w)=',f3.1,'%, PI=17-26, Energy=',
     $f7.1,a4,', Conf.Str.=',a8,a4)

        wc=11.75
        ninc=8.25/inc
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
c
        write(11,1001) stl,stl
c
        do 2006 ll = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        wc = wc + inc
c
        densw=dens/sm2
        denminw=denmin/sm2
c
        write(11,1901) wc,dens,denmin
 2006   continue
        go to 1999
c
c ***********************************************************************
c Section for Medium Plastic Strength prediction tables
c ***********************************************************************
c
212     read(10,*) pc,cp,inc,wv
        pc=pc*sml
        cp=cp*sml
c
        title='Strength - Medium Plastic Soils'
c
        write(11,180) title
        pcw=pc/sml
        cpw=cp/sml
        write(11,1812) wv,pi,pcw,st3,cpw,st3
 1812   format(/10x,'V(w)=',f3.1,'%, PI=',f5.2,', Energy =',
     $f6.1,a4,', Conf.Str.=',f5.1,a4)
```

```
c
        wc=11.75
        ninc=8.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
        nchk=2
        call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
c
        write(11,1002) st1,st1,st2,st2
c
        do 2007 ii = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        call strnth (xxs,ss,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
     1  wv,pi,nnn)
        wc = wc + inc
c
        densw=dens/sm2
        denminw=denmin/sm2
        qcw=qc/sm1
        qcminw=qcmin/sm1
c
        write(11,1902) wc,densw,denminw,qcw,qcminw
 2007   continue
        go to 1999
c
c ***********************************************************************
c Section for Medium Plastic, Volume change on Soaking prediction table
c ***********************************************************************
c
213     read(10,*) pc,cp,inc,wv
        pc=pc*sm1
        cp=cp*sm1
        title='Volume change on soaking - Medium
     $ Plastic Soils'
c
        write(11,180) title
        pcw=pc/sm1
        cpw=cp/sm1
        write(11,1812) wv,pi,pcw,st3,cpw,st3
c
        wc=11.75
        ninc=8.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
        nchk=2
        call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
```

```
      write(11,1003) stl,stl
c
      do 2008 ll = 1,ninc
      scs=0.0
      call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1 wv,pi,scs,nnn)
      call strnth (xxs,ss,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
     1 wv,pi,nnn)
      wc = wc + inc
c
      densw=dens/sm2
      denminw=denmin/sm2
c
      write(11,1903) wc,densw,denminw,qc,qcmin
 2008 continue
      go to 1999
c
c ************************************************************************
c Section for Medium Plastic Prestress prediction tables
c ************************************************************************
c
214   read(10,*) pc,cp,inc,wv
      pc=pc*sml
      cp=cp*sml
      title='Pre-Stress - Medium Plastic Soils'
c
      write(11,180) title
      pcw=pc/sml
      write(11,1811) wv,pcw,st3,st6,st3
c
      wc=11.75
      ninc=8.25/inc
c
      nchk=1
      call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
c
      write(11,1004) st2,st2
c
      do 2009 ll = 1,ninc
      scs=0.0
      call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1 wv,pi,scs,nnn)
      wc = wc + inc
c
      densw=dens/sml
      denminw=denmin/sml
c
      write(11,1904) wc,densw,denminw
 2009 continue
      go to 1999
```

```
c
c ***********************************************************************
c Section for Medium Plastic Strength Intercept prediction tables
c ***********************************************************************
c
215     read(10,*) pc,cp,inc,wv
        pc=pc*sml
        cp=cp*sml
c
        title='Strength Intercept - Medium Plastic Soils'
c
        write(11,1825) title
 1825   format(//////15x,a60)
        pcw=pc/sml
        write(11,1815) wv,pcw,st3,st6,st3
 1815   format(/9x,'V(w)=',f3.1,'%, PI=17-26, Energy=',
     $f7.1,a4,', Conf.Str.=',a8,a3)

c
        wc=11.75
        ninc=8.25/inc
c
        nchk=1
        call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
        nchk=2
        call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
c
        write(11,1015) st1,st1,st2,st2
1015    format(10x,'________________________________________',
     $'____________________',//24x,'Expected',4x,'Expected',4x,'Expected'
     $,4x,'Expected',/14x,'Water',5x,'Dry',9x,'Min Dry',5x,'Strength'
     $,4x,'Min.Str',/13x,'Content',4x,'Density',5x,'Density',5x,
     $'Intercept',3x,'Intercept',/15x,'(%)',5x,a9,3x,
     $a9,5x,a5,7x,a5,/10x,'_________________________',
     $'______________________________________________',/)
c
        do 2010 11 = 1,ninc
        scs=0.0
        call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1  wv,pi,scs,nnn)
        call strnth (xxs,ss,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
     1  wv,pi,nnn)
        wc = wc + inc
c
        qcc=qc
        qcminn=qcmin
        if (qc .lt. 0.0) then
        qcc=0.0
        else
        endif
```

```
      if (qcmin .lt. 0.0) then
      qcminn=0.0
      else
      endif
c
      densw=dens/sm2
      denminw=denmin/sm2
      qccw=qcc/sm1
      qcminnw=qcminn/sm1
c
      write(11,1902) wc,densw,denminw,qccw,qcminnw
 2010 continue
      go to 1999
c
c *******************************************************************
c Section for Medium Plastic Strength Angle prediction tables
c *******************************************************************
c
216   read(10,*) pc,cp,inc,wv
      pc=pc*sm1
      cp=cp*sm1
c
      title='Strength Angle - Medium Plastic Soils'
c
      write(11,180) title
      pcw=pc/sm1
      write(11,1811) wv,pcw,st3,st6,st3

c
      wc=11.75
      ninc=8.25/inc
c
      nchk=1
      call xxi(xxd,sd,nd,coed,alamd,nnn,nchk)
      nchk=2
      call xxi(xxs,ss,ns,coes,alams,nnn,nchk)
c
      write(11,1016) st1,st1
1016  format(10x,'______________________________________________',
     $'____________________',//24x,'Expected',4x,'Expected',4x,'Expected'
     $,4x,'Expected',/14x,'Water',5x,'Dry',9x,'Min Dry',5x,'Strength'
     $,4x,'Min.Str',/13x,'Content',4x,'Density',5x,'Density',6x,
     $'Angle',7x,'Angle',/15x,'(%)',5x,a9,3x,a9,
     $5x,'(deg)',7x,'(deg)',/10x,'__________________________________',
     $'_________________________',/)
c
      do 2011 ll = 1,ninc
      scs=0.0
      call density (xxd,sd,nd,wc,dens,denmin,coed,alamd,pc,vd,
     1 wv,pi,scs,nnn)
```

```
          call strnth (xxs,as,ns,wc,dens,qc,qcmin,coes,alams,cp,vd,
      1   wv,pi,nnn)
          wc = wc + inc
c
          densw=dens/sm2
          denminw=denmin/sm2
c
          write(11,1902) wc,densw,denminw,qc,qcmin
 2011     continue
          go to 1999
c
c *********************************************************************
1999      go to 1111
1000      stop
          end
c
c *********************************************************************
c                              MAIN PROGRAM ENDS
c *********************************************************************
c
c
c *****************************************************:
           subroutine xxi(xx,s,nl,coe,alam,nrn,nrchk)
           real v(10,10),xx(10,10),vr(10),r(10),coe(10)
c          calculation of xx-1 matrix

          if (nrchk .eq. 1) then
          go to (9101,9101,9101,9104,9105,9106,9106,
      $9106,9109,9106,9106) nrn
          else
          go to (9101,9102,9103,9104,9105,9106,9107,
      $9108,9109,9110,9111) nrn
          endif

9101      call lden(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9102      call lstr(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9103      call lvol(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9104      call lprs(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9105      call lsps(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9106      call hden(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9107      call hatr(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
9108      call hvol(n,nl,s,alam,ncof,coe,r,v)
          go to 9999
```

```
9109    call hprs(n,nl,s,alam,ncof,coe,r,v)
        go to 9999
9110    call hcee(n,nl,s,alam,ncof,coe,r,v)
        go to 9999
9111    call hphi(n,nl,s,alam,ncof,coe,r,v)

c       n = number of data points
c       nl = number of independent variables
c       s = square root of the MSE
c       coe = coefficients of regression eqn.
c       r(i) = mean values of the independent variables

9999    k = 1
        do 20 i = 1,nl
        k=k+1
        do 20 j = k,nl
        v(i,j) = v(j,i)
20      continue
        s2 = s*s
        do 3 i = 1,nl
        vrl = 0
        do 2 j = 1,nl
        vrl = vrl + v(i,j)*r(j)
 2      continue
        vr(i) = vrl/s2
 3      continue
        rvrl = 0
        do 4 i = 1,nl
        rvrl = rvrl + vr(i)*r(i)
 4      continue
        xx(1,1) = rvrl + 1.0/float(n)
        do 5 j = 1,nl
        xx(1,j+1) = -vr(j)
        xx(j+1,1) = -vr(j)
 5      continue
        do 6 i = 1,nl
        do 6 j = 1,nl
        xx(i+1,j+1) = v(i,j)/s2
 6      continue
c       calculation of xx-1 matrix ended
        return
        end
c       ***********************************************************
        subroutine density (xx,sd,nd,wc,dens,denmin,coe,alam,pc,vd,
     1  wv,pi,ascs,npn)
c
        real var(10),va(10),xx(10,10),coe(10)
        nvar = nd + 1
        dw = wv
```

```
      do 70 kk =1,3
      if(kk.eq.2) dw = -dw
      if (kk .gt. 2) dw = 0
      wl = wc + dw
c
      go to (401,401,401,404,405,406,406,406,406,
     $409,406,406) npn
c
401   var(1) = 1.0
      var(2) = 1.0/wl
      var(3) = wl*sqrt(pi/7.2)
      go to 444
404   var(1) = 1.0
      var(2) = wl*sqrt(pi/11.0)
      var(3) = sqrt(pc)
      var(4) = wl*wl*pc*1.0e-5
      go to 444
405   var(1) = 1.0
      var(2) = sscs
      var(3) = wl*sqrt(pi/7.2)
      var(4) = sqrt(pc)
      var(5) = wl*wl*pc*1.0e-5
      go to 444
406   var(1) = 1.0
      var(2) = 1.0/wl
      var(3) = wl*pc/100.
      var(4) = sqrt(pc)/wl
      var(5) = sqrt(pc)*wl*wl/1000.
      go to 444
409   var(1) = 1.0
      var(2) = sqrt(pc)
      var(3) = wl*wl*pc/100000.


444   if (kk .gt. 2) go to 70
c
      xx2 = 0.0
      do 30 i = 1,nvar
      xx1 = 0
      do 40 j = 1,nvar
      xx1 = xx1 + xx(i,j)*var(j)
 40   continue
      xx2 = xx2 + xx1*var(i)
 30   continue
c
      va(kk) = alam*ad*sqrt(xx2)
 70   continue
      vd = va(1)
      if (va(2).gt.va(1)) vd = va(2)
      den1 = 0.0
```

```
        do 80 i = 1,nvar
        denl = denl + coe(i)*var(i)
 80     continue
        dens = denl
        denmin = dens - vd
        return
        end
c       ***********************************************************
        subroutine strnth (xx,ss,ns,wc,dens,qc,qcmin,coe,alam,cp,vd,
     1  wv,pi,ngn)
        real var(10),va(10),xx(10,10),coe(10)
        nvar = ns + 1
        dw = wv
        do 70 kk =1,5
        if(kk.eq.2) then
        dw = -dw
        elseif (kk.eq.3) then
        vd = -vd
        elseif (kk.eq.4) then
        dw = -dw
        elseif (kk.eq.5) then
        vd = 0.0
        dw = 0.0
        else
        endif
        wl = wc + dw
        den = dens + vd
        go to (502,502,503,503,503,507,507,508,
     $508,510,510) ngn
c
c -------Strength Prediction--------
502     var(1) = 1.0
        var(2) = wl*wl
        var(3) = sqrt(den*wl*cp*pi/7.2)
        var(4) = cp
        go to 555
c
c -------Swelling Prediction--------
503     var(1) = 1.0
        var(2) = wl
        var(3) = sqrt(cp)
        var(4) = sqrt(cp)/den
        var(5) = sqrt(pi/20.)
        go to 555
c -----Medium Plastic strength Prediction----
507     var(1) = 1.0
        var(2) = wl*wl*sqrt(pi/7.2)
        var(3) = sqrt(pi/7.2)
        var(4) = sqrt(den*wl*cp*pi/7.2)/1000.
        var(5) = sqrt(den)
        go to 555
```

```
c -----Medium Plastic Swelling Prediction----
508     var(1) = 1.0
        var(2) = wl
        var(3) = sqrt(cp)
        var(4) = sqrt(cp)/den
        var(5) = sqrt(pi/20.)
        go to 555
c -----Medium Plastic cee prediction---------
510     var(1) = 1.0
        var(2) = wl
        var(3) = wl*sqrt(den)
c
c
555     if (kk.eq.5) go to 70
c
        xx2 = 0.0
        do 30 i = 1,nvar
        xx1 = 0
        do 40 j = 1,nvar
        xx1 = xx1 + xx(i,j)*var(j)
 40     continue
        xx2 = xx2 + xx1*var(i)
 30     continue
c
        va(kk) = alam*ss*sqrt(xx2)
 70     continue
        vs = va(1)
        do 71 l = 2,4
        if (abs(va(l)).gt.abs(vs)) vs = va(l)
71      continue
        str = 0.0
        do 80 i = 1,nvar
        str = str + coe(i)*var(i)
 80     continue
        qc = str
        if ((ngn .eq. 3) .and. (qc .gt. 0.0)) then
        qcmin = qc + abs(vs)
        elseif ((ngn .eq. 3) .and. (qc .lt. 0.0)) then
        qcmin = qc - abs(vs)
        elseif ((ngn .eq. 8) .and. (qc .gt. 0.0)) then
        qcmin = qc + abs(vs)
        elseif ((ngn .eq. 8) .and. (qc .lt. 0.0)) then
        qcmin = qc - abs(vs)
        else
        qcmin = qc - vs
        endif
c
        return
        end
c ******************************************************************
```

```
c ****************************************************************
      subroutine lden(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=37
      nl=2
      s=60.7216
      alam=2.03
      ncof=3
      coe(1)=2834.3348
      coe(2)=-5513.8663
      coe(3)=-35.9433
      r(1)=.0658
      r(2)=18.1133
      v(1,1)=.19802e+7
      v(2,1)=7105.62725
      v(2,2)=32.07062

      return
      end
c ****************************************************************
      subroutine lstr(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=18
      nl=3
      s=46.75456
      alam=2.544
      ncof=4
      coe(1)=181.98
      coe(2)=-.633955
      coe(3)=.13625
      coe(4)=-.812812
      r(1)=310.1336
      r(2)=2545.0724
      r(3)=176.5489
      v(1,1)=.0426
      v(2,1)=-0.01511
      v(2,2)=0.00912
      v(3,1)=.12291
      v(3,2)=-.07496
      v(3,3)=.64426

      return
      end
c ****************************************************************
```

```
      subroutine lvol(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)
      n=23
      nl=4
      s=0.11038
      alam=2.477
      ncof=5
      coe(1)=-.94574
      coe(2)=0.011176
      coe(3)=0.02416
      coe(4)=2.817755
      coe(5)=1.05697
      r(1)=15.1687
      r(2)=5.30393
      r(3)=.003
      r(4)=.6817
      v(1,1)=.00011
      v(2,1)=.00062
      v(2,2)=.01034
      v(3,1)=-1.25995
      v(3,2)=-17.91752
      v(3,3)=32184.0
      v(4,1)=.00472
      v(4,2)=.03183
      v(4,3)=-66.5676
      v(4,4)=.42247
      return
      end
c *************************************************************
      subroutine lprs(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)
      n=37
      nl=3
      s=2.797
      alam=2.036
      ncof=4
      coe(1)=155.40329
      coe(2)=-2.6103
      coe(3)=-3.4265
      coe(4)=5.7334
      r(1)=14.6544
      r(2)=31.7572
      r(3)=2.7036
      v(1,1)=.2128
      v(2,1)=.07872
      v(2,2)=.10206
      v(3,1)=-.56301
      v(3,2)=-.23058
      v(3,3)=1.65527
      return
      end
```

```
c ************************************************************
      subroutine lsps(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=35
      nl=4
      s=12.8644
      alam=2.042
      ncof=5
      coe(1)=224.17
      coe(2)=1.1312
      coe(3)=-4.824
      coe(4)=-4.999
      coe(5)=19.265
      r(1)=34.1358
      r(2)=18.0132
      r(3)=31.7469
      r(4)=2.6826
      v(1,1)=.02408
      v(2,1)=-.04483
      v(2,2)=3.07658
      v(3,1)=.03616
      v(3,2)=1.30378
      v(3,3)=2.22642
      v(4,1)=.02606
      v(4,2)=-9.80721
      v(4,3)=-4.90634
      v(4,4)=35.40474

      return
      end
c ************************************************************
      subroutine hden(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=30
      nl=4
      s=20.1289
      alam=2.06
      ncof=5
      coe(1)=1935.2877
      coe(2)=-6597.7597
      coe(3)=-.807586
      coe(4)=197.8369
      coe(5)=-.41862
      r(1)=.0641
      r(2)=186.3976
      r(3)=2.1855
      r(4)=8.5359
      v(1,1)=.13525e+8
      v(2,1)=-391.228
      v(2,2)=.39105
```

```
      v(3,1)=-96420
      v(3,2)=-28.84
      v(3,3)=3395.4
      v(4,1)=39341.
      v(4,2)=-9.364
      v(4,3)=405.15
      v(4,4)=295.47

      return
      end
c *****************************************************************
      subroutine hstr(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=80
      nl=4
      s=56.86453
      alam=2.31
      ncof=5
      coe(1)=-956.04201
      coe(2)=-.53116395
      coe(3)=-66.9845
      coe(4)=29.153359
      coe(5)=34.56071
      r(1)=458.0134
      r(2)=1.7466
      r(3)=3.4624
      r(4)=42.1506
      v(1,1)=.00533
      v(2,1)=-3.4626
      v(2,2)=5910.54897
      v(3,1)=-.15698
      v(3,2)=-58.48163
      v(3,3)=44.12167
      v(4,1)=.37149
      v(4,2)=-372.9975
      v(4,3)=2.1783
      v(4,4)=124.6738

      return
      end
c *****************************************************************
      subroutine hvol(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=38
      nl=4
      s=0.14446
      alam=2.373
      ncof=5
```

```
      coe(1)=-.202063
      coe(2)=-.053174
      coe(3)=-.498867
      coe(4)=1022.7836
      coe(5)=.145374
      r(1)=15.5811
      r(2)=18.2593
      r(3)=.01
      r(4)=1.0334
      v(1,1)=.00025
      v(2,1)=.0004411
      v(2,2)=0.00292
      v(3,1)=-.86873
      v(3,2)=-5.4292
      v(3,3)=10253.
      v(4,1)=-.00189
      v(4,2)=.00191
      v(4,3)=-3.37954
      v(4,4)=.15191

      return
      end
c ************************************************************
      subroutine hprs(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=24
      nl=2
      s=51.0615
      alam=2.08
      ncof=3
      coe(1)=-148.44558
      coe(2)=26.97
      coe(3)=-67.6743
      r(1)=33.763
      r(2)=2.3436
      v(1,1)=5.75377
      v(2,1)=-20.62309
      v(2,2)=261.85737

      return
      end
c ************************************************************
      subroutine hcee(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=23
      nl=2
      s=1.43583
      alam=2.454
      ncof=3
```

```
      coe(1)=-102.78945
      coe(2)=42.4585
      coe(3)=-.82582
      r(1)=17.0435
      r(2)=716.5295
      v(1,1)=61.66452
      v(2,1)=-1.49671
      v(2,2)=0.03639

      return
      end
c *****************************************************************
      subroutine hphi(n,nl,s,alam,ncof,coe,r,v)
      real v(10,10),r(10),coe(10)

      n=23
      nl=2
      s=1.43583
      alam=2.454
      ncof=3
      coe(1)=47.549
      coe(2)=-7.81772
      coe(3)=.150606
      r(1)=17.0435
      r(2)=716.5295
      v(1,1)=9.30521
      v(2,1)=-.22585
      v(2,2)=0.00549

      return
      end
c *****************************************************************
```

COVER DESIGN BY ALDO GIORGINI